Ontario Ministry of Labour
Research Branch

Employment and Immigration Canada

Northwestern Ontario Manpower Adjustment Study

Component Study Number 5

Projections of Total Labour Force in Northwestern Ontario, to 1981

by Frank A. Edwards

Ontario Ministry of Labour

Hon. Bette Stephenson, M.D., Minister
T.E. Armstrong, Q.C.; Deputy Minister

Employment and Immigration Canada

Hon. Bud Cullen, Minister
J.L. Manion, Chairman

Worth Lake, Kenora

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PREFACE

The Northwestern Ontario Manpower Adjustment Study was undertaken by the Research Branch of the Ontario Ministry of Labour as one of the projects for the Canada/Ontario Interim Northlands Subsidiary Agreement under the General Development Agreement. The funds for this project were provided by Employment and Immigration Canada and by the Ontario Regional Priority Budget.

The objective of the Study is to provide information required for the development of policies and programmes designed to relieve structural imbalances in the labour market in Northwestern Ontario. The Study comprises ten component projects dealing with labour supply, labour demand, turnover and absenteeism, migration, and the labour market intentions of graduating students. A complete list of these projects appears inside the back cover.

The present report, "Projections of Total Labour Force in Northwestern Ontario, to 1981," uses a new methodology to evaluate the trends in the growth of the labour force in Northwestern Ontario during the next three years, and focuses on the effects that the natural increase of the population, net migration, and changes in the participation rates will have on these trends. The opinions expressed in this report are those of the author only, and do not reflect the official views of the Ontario Ministry of Labour, Employment and Immigration Canada, the Ontario Ministry of Treasury, Economics and Intergovernmental Affairs, or the Department of Regional Economic Expansion.

We would like to take this opportunity to thank the many individuals and organisations who helped us to complete this Study. Thanks are due to Employment and Immigration Canada and to the Ontario Regional Priority Budget, whose financial support made the Study possible. We also thank Dr. L. O. Stone, Professor Noah M. Meltz, and Professor C. A. Jecchinis; the members of the Committee On Getting and Holding Manpower in Northwestern Ontario; and Mr. Cliff McIntosh and Mr. Bob Michels of the Quetico Centre, all of whom helped during the planning stages of the Study. For supplying data indispensable to our research we thank the staff at Lakehead University and Confederation College; the Boards of Education in the Districts of Thunder Bay, Rainy River, and Kenora; and the employers and other persons too numerous to name whose contributions assisted us immeasurably. For cooperation and perseverance which facilitated our work we are indebted to many officials in both the Federal and Provincial Governments, and especially to the members of the Federal-Provincial Management Committee for the Interim Northlands Subsidiary Agreement. We are indebted as well to Mr. Michael Ryval and Mr. Charles Bogue, who edited the drafts of these reports for publication, and to the many persons on the clerical and secretarial staff of the Ontario Ministry of Labour whose assistance made it possible to complete these reports. For their encouragement and support we thank Mr. John Kinley and Mr. M. Skolnik, who were the Directors of the Research Branch at the Ontario Ministry of Labour while this Study was in progress, and Mr. G. S. Swartz, the current Director of the Branch. Finally, special thanks go to the author of the present report, Frank A. Edwards, for his work on this project.

Mel Soucie
Employment & Immigration Canada
Federal Co-Chairman
Project Management Committee

Farid Siddiqui
Ontario Ministry of Labour
Provincial Co-Chairman
Project Management Committee

NORTHWESTERN ONTARIO MANPOWER ADJUSTMENT STUDY

CHAPTER I

INTRODUCTION

This report evaluates the trends in the growth of the labour force in Northwestern Ontario[1] until the year 1981.[2] The distinctive feature of this analysis is its recognition that historical data are the end-product of many complex interactions, and that meaningful projections can only be made when the interactions that generate the observable facts are understood.[3] For this reason, rather than present "straight-line" or "fixed-coefficient" extrapolations of past data, this report identifies some of the factors underlying the growth of the labour force, and demonstrates their dynamic effects on this growth. Such an analysis is of practical value because the essential dynamic effects of these factors often persist in spite of many of the government actions that are conventionally undertaken to improve the growth trends in the labour force. By explicitly describing some of these complex interactions and their dynamic effects on the growth of the labour force, the analysis presented in this report should assist in understanding the response of the Northwestern Ontario Region to specific social, political, or economic changes, and also assist, when desirable, in designing government policies that can achieve long-term results.

There are three major sources of growth in the labour force: the natural increase of the population, net migration, and changes in the participation rates.[4] Separate projections of these contributions to growth in the labour force and the resulting trends of growth in the total labour force are made for each of the male and female primary and secondary age groups in the labour force.[5] The actual projections

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[1] "Northwestern Ontario" refers to the Northwestern Ontario Economic Region, defined by P. Camu, E. P. Weeks, and Z. W. Sametz in Economic Geography of Canada (Toronto: Macmillan, 1964), and recognised by the Ontario Ministry of Treasury, Economics, and Intergovernmental Affairs as one of its five Planning Regions for the Province of Ontario. Unless otherwise specified, the term "Region" as used in this report is synonymous with the above geographical designation.

[2] The analysis undertaken in this report covers the Region as a whole. Although it is possible to disaggregate the results by Census Districts, in order to make accurate projections of the trends of growth in the labour force within each District it would be necessary to take into account the relationships between the Districts. This process was considered to be beyond the scope of this project.

[3] In the more sophisticated econometric studies specific relations are derived from interactions based on economic theory; the coefficients in these relations are then fixed by "fitting" them to historical data. In the present study the relations identified are based primarily on the work of Nathan Forrester in his Life Cycle of Economic Development, 2nd ed. (Cambridge, Mass.: Wright-Allen Press, 1973).

[4] Participation rates are defined as the ratio between the number of persons in the labour force (whether they are employed or not) and the total number of persons in the working-age population. In this report the working age is regarded as 15 to 64, inclusive.

[5] The primary age group consists of all males and females 25 to 44 years of age, and the secondary age group consists of all males and females 15 to 24 and 45 to

are made with a computer model[6] that has been designed to reproduce the dynamic effects of the factors influencing growth in the labour force. Two kinds of projections are made. The first assumes no government policy initiative. The second incorporates a variety of policies, including those that traditionally accompany growth and industrialisation, such as an increased flow of capital, greater levels of productivity, and a shorter work week. The resulting projections test the effect that each of these policies will have on the growth of the labour force.

From the projections assuming no policy initiative it is forecast that the labour force in Northwestern Ontario will continue to grow during the 1970s, but that the rate of this growth should begin to decrease after 1973.[7] However, the labour force should continue to grow until well after 1980 before beginning to decline.[8] In absolute numbers, the labour force in Northwestern Ontario grew by less than 13 thousand during the 1960s and is expected to grow by approximately 18 thousand during the 1970s, but it is unlikely to grow by as much as 3 thousand during the 1980s.

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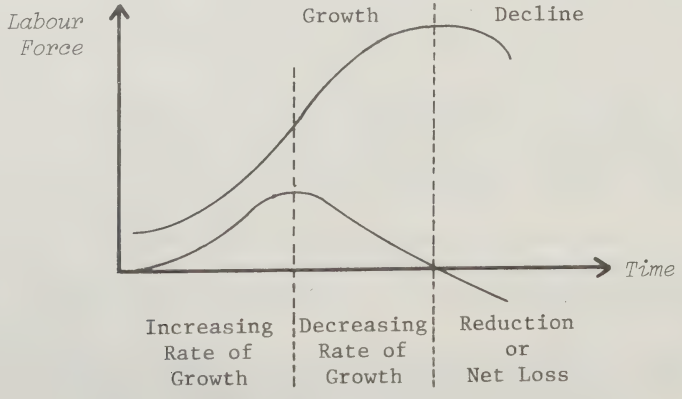
64 years of age. The female labour force is not considered to be entirely within the secondary age group, as is more usual.

[6]The major variables used in this model are considered to be interactive; that is, they both determine and are themselves determined by other variables to varying degrees and with appropriate delays. The use of interactive variables has resulted in the application of a relatively new computer simulation method known as "feedback analysis." The computer model developed here is based on a technique, called Systems Dynamics, which uses this type of analysis. Systems Dynamics was developed at M.I.T. by Jay Forrester (Principles of Systems [Cambridge, Mass.: Wright-Allen Press, 1969]).

[7]At the time of writing no data were available to confirm whether this had occurred; all of the data after 1971 are projections. The projections have been continued until the year 2020 to provide a context within which to interpret the trends up to 1981. These long-range projections were made on the assumption that the exogenous factors affecting growth in the labour force in 1981 (e.g., capital flows, productivity levels, capital-output ratio, and the age distribution of migrants) would remain constant until 2020.

[8]The terminology used to describe growth trends is explained by the following graph. The top line shows the size of the labour force in absolute numbers; the bottom line shows the change in the size of the labour force from one year to the next.



Several factors are responsible for this trend. The contribution of the natural increase in the population to the labour force of the Region should continue to grow until well after 1980, but the rate of growth of this contribution should decrease after the mid-1970s. There should also be a decrease in the rate of growth of the contribution made by changes in participation rates after their striking rise during the 1960s. After 1978 and through most of the 1980s the contribution made by changes in participation rates is expected to reduce the labour force, but it should again increase the labour force thereafter. Migration is projected to increasingly reduce the labour force after 1973; this effect should continue into the 1980s before stabilising at a rate of net out-migration from the experienced labour force of about 500 persons a year.

The projected trends in the growth of each of the four component groups[9] in the total labour force reflect, to a great extent, the assumptions made about the relative demands that each of the production sectors[10] makes on each of these groups, and the age and sex distributions of migrants entering and leaving the labour force.[11] The results show that during the 1970s the rates of growth in both primary labour force groups decrease, reaching about half their 1971 levels by 1981. Contributing to this decrease is the fact that the additions to these labour force groups from the natural increase in the population cease to grow each year as they have in the past.[12] Furthermore, the additions to these labour force groups from yearly changes in the participation rates and from migration become increasingly smaller, or actually reduce these labour force groups.

The rates of growth drop even more sharply in the secondary labour force groups during the 1970s. This trend is due to a significant reduction in the yearly additions to these labour force groups from the natural increase in the population and from changes in the participation rates. In fact, changes in the participation rates should reduce both male and female secondary labour force groups in the late 1970s. Migration is expected to remain almost constant at a small net out-migration from both secondary labour force groups.

The second set of projections, in which various policy initiatives were included, shows that the basic growth trend in the labour force in Northwestern Ontario is not likely to be significantly affected by any of the policy initiatives tested. Although these policies may increase or decrease the projected size of the labour

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[9] I.e., the male and female primary and secondary age groups.

[10] This analysis incorporates three production sectors: food, goods, and services. The food sector consists of the S.I.C. industry groups: Agriculture; and Fishing and Trapping. The goods sector consists of: Forestry; Manufacturing; Mining; and Construction. The services sector consists of: Transportation, Communications and Other Utilities; Trade; Finance, Insurance and Real Estate; Community, Business and Personal Services; and Public Administration and Defence. Each sector is assumed to demand a different ratio of male to female and primary to secondary labour. These ratios are also assumed to change over time as a result of factors such as changing technology, the introduction of anti-discrimination laws, and the changing awareness of employers of alternative sources of labour.

[11] The age and sex distributions of migrants are difficult to forecast because they depend to a great extent on government policy and people's perspectives on northern development. The distributions used in this analysis are based on Statistics Canada's Taxation Data, Special Tabulations.

[12] Included in the natural population increase are the aging, births, and deaths associated with migrants in previous years.

force in any one year, they cause internal pressures to build up in the economic system that are later released, re-establishing the original trend of growth in the labour force. These projections suggest that only policy initiatives designed to alter the dynamic relations underlying growth in the labour force can have any lasting effect on the future development of Northwestern Ontario.

The contents of the remainder of this report may be summarised as follows: Chapter II outlines some of the methodological considerations central to this study. A more technical discussion of the methodology is provided in Appendix I for those who are already familiar with forecasting techniques and who wish to know more about the relatively new approach of feedback analysis that is used here.[13] Chapter III presents the main findings of this project, i.e., the projected trends until 1981 assuming no policy initiatives. The assumptions used in making the projections are described in detail in Appendix II, and the tests of alternative policy initiatives appear in Appendix III.

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[13] A detailed description of the computer model is available from the Research Branch at the Ontario Ministry of Labour upon written request.

CHAPTER II

METHODOLOGY

This chapter is divided into two parts. The first, a review of manpower forecasting techniques, describes the assumptions that are made, and the attitudes towards the labour market that are implied, in several different methodological approaches. The second part discusses the methodological principles adopted in the present study, and notes in particular the way qualitative, verbal information about adjustment processes in the labour market can be incorporated in a computer model.

The central point of this chapter can be stated at the outset. Data are the end-product of extremely complex interactions, whose form is virtually impossible to derive from an analysis of the data alone. Yet it is these interactions that govern growth in the labour force. An understanding of these interactions requires, in place of traditional analytical techniques for evaluating labour market data, a systems approach capable of illuminating the structure of the processes occurring in the labour market. The interactions that make up these processes need to be postulated "in theory" or from "expert opinion" to create the structure of a model. Data can then be entered into the model to develop a data base for testing policy initiatives. Such an approach is described in the second part of this chapter.

1. A review of manpower forecasting techniques

The purpose of manpower forecasting is to obtain an estimate of the discrepancies between the expected requirements for labour (by occupation, industry, skill, etc.) and the expected supply of labour. The rationale behind forecasting is that market adjustment mechanisms[1] cannot be relied on to eliminate discrepancies between supply and demand in any satisfactory way; there are simply too many rigidities in the labour market to allow perfect adjustment. For example, workers cannot respond to price adjustments quickly or effectively because of restrictions on their mobility, the lack of sufficient information, and the length of time required to undergo appropriate training for new occupations. The public must intervene to facilitate adjustments in the labour market, and, in order to do so, it requires a forecast of the adjustments that are needed.

It is evident that both labour demand and labour supply are components of manpower forecasting, because both demand and supply are reflected in any real data used in the analysis. Most methodologies of manpower forecasting are concerned with both components to the extent that they must include some way of separating the effects of demand and supply in the data they use (or some way of combining the effects of demand and supply in their model to reflect the available data). This is the only way in which traditional analytical methods recognise that data are the end-product of related interactions. Indeed, although a great deal of the literature on the economic analysis of the labour market is devoted to the relation between these supply and demand effects, and although much of the development in statistical and analytical techniques for evaluating data also focuses on this problem, the complexity of the interactions generating these data has not been generally recognised. This fail-

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[1] I.e., adjustments occurring as a result of price and wage changes that would be expected according to classical economic theory.

ure constitutes the principal weakness of most traditional forecasting techniques.

Methodologies of manpower forecasting fall into two broad categories: forecasts of outcomes likely only if a specified course of action is taken, and forecasts of outcomes likely if no effort is made to secure a particular result. The first category, referred to as a "policy-conditional forecast," assumes that some control can be exercised over the actions taken; the second, referred to as an "onlooker forecast," assumes no such control.[2] In practice this distinction is somewhat arbitrary, because there is always some form of "control" by the government, even if it is exercised merely by publishing an onlooker forecast.

A further distinction can be made between those methodologies that are "theoretical" and those that are "pragmatic." The theoretical approach must assume that labour market adjustments take place exclusively as a result of price changes. These adjustments are known to be imperfect. Nevertheless, the theoretical approach assumes that improvements in the adjustment processes can still be brought about by manipulating market variables. In order to find out what effect such manipulation might have, a mathematical description is developed of adjustments occurring as a result of price adjustment mechanisms. This description is then used to determine what effect a change in any of the variables may have on the predictions of future adjustments. Because the mathematical description is derived from historical data the relations between the variables included in the description are assumed to remain constant. Any action undertaken to change any of the variables must also be assumed to have no secondary effects that might change these fixed relations, otherwise projections could not be made.

It should be noted that a matching of supply and demand is interpreted as a matching of the expressed supply in the market and the expressed demand at the given prices and wage rates. It is expected, for example, that more people would enter a given occupation (i.e., that the expressed supply would be greater) if the wage rates for that occupation were higher. This greater supply may include qualified people who previously wished to enter this occupation, but who did not do so because the wage rates were too low. In the theoretical approach these people are excluded from the supply unless their desire to enter a particular occupation is made explicit. The levels of supply and demand are thus assumed to depend on prices and wage rates.

This type of analysis requires a highly theoretical knowledge, generally including a knowledge of price elasticities.[3] Difficulties in this approach arise from the lack of adequate theoretical knowledge of labour market adjustments, the lack of appropriate data, the exclusion of adjustments occurring for reasons other than "prices,"[4] and an inability to build into the analysis "real-world" processes that are not reversible.[5] Despite these difficulties, some attempts at manpower forecast-

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[2] B. Ahamad and M. Blaug, eds., The Practice of Manpower Forecasting: A Collection of Case Studies (San Francisco: Jossey-Bass Inc., 1973), p. 5.

[3] Price elasticities take many forms. For example, the elasticity of substitution between occupations reflects the number of workers who would change occupations for a given wage differential (i.e., the differential between the "price" of labour in each occupation).

[4] Except those occurring as random variations from predictions based on prices.

[5] For example, the shift in people's perceptions that accompanies growing experience in the labour market.

ing have been made with this methodology.[6]

The pragmatic approach is more common. It accepts that manpower forecasting is aimed at the difference between actual and desirable market developments. Labour supplies are estimated by determining the natural growth of the population, migration, changes in participation rates, and the influence of the education system on occupations, skills, etc. Demand is estimated through an analysis of industrial development, often with reference to a desired industrial strategy, from which manpower requirements and consequent excesses and shortages in supply can be determined. Discrepancies between supply and demand are assumed to be those that would actually occur in the absence of specific policy initiatives.

The matching of supply and demand in the pragmatic approach is interpreted as the matching of the desired or required labour supply and labour demand and not, as in the theoretical approach, the matching of an expressed supply and demand that depend on prices and wage rates. Although this method avoids the problems arising from an inadequate theoretical knowledge of the effects of prices, it excludes some of the adjustments that actually take place as a result of changes in prices and wage rates, even though these adjustments are imperfect. Further difficulties often arise from the techniques that are used to estimate supply and demand. Knowledge of the theory implicit in the technique may be inadequate,[7] or the appropriate data may be difficult to get. The statistical techniques of regression, correlation, cohort analysis, trend analysis, and "percentage" analysis are all oriented towards obtaining fixed coefficients for the estimated relations based on historical data, much as they are in the theoretical approach. These fixed coefficients thus represent the past involvements of the government and the effects of other past external conditions, but give no indication of what might happen if the government altered its course of action or if external conditions changed.

Still another problem is that the need to establish fixed coefficients from past data limits the relationships that are estimated to those involving variables for which past data are available. This limitation usually results in the estimation of very aggregate or composite relations, and the variables are often transformed into abstract quantities such as logarithms and exponents.[8]

One final distinction can be made in each of the categories mentioned above: the way in which the accuracy of the results is judged. Some forecasters attempt to predict the actual data exactly, and consider an "accurate" forecast to be one that matches or nearly matches those data. Others seek to identify the adjustment processes that generate the data in order to find a dynamic that is not disclosed by the data alone; the correct identification of the adjustment mechanisms is more important to these forecasters than the accurate prediction of data. The first approach, which is predominant, is most often identified with Milton Friedman.[9] Implicit in this view is the assumption that those elements of human behaviour not accounted for in the

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[6] See Ahamad and Blaug, Manpower Forecasting, for references.

[7] For example, there is an extensive and often conflicting literature devoted to the theory behind input-output analysis, which is often used to evaluate industrial development, and to the theory behind productivity analysis, which is often used to evaluate the relation between industrial output and labour requirements.

[8] See the use that N. M. Meltz and G. P. Penz have made of the squared value of the unemployment rate for projecting industry sector employment, in Department of Manpower and Immigration, Canada's Manpower Requirements in 1970 (1968), p. 7.

[9] See Milton Friedman, Essays in Positive Economics (Chicago: University of Chicago Press, 1956).

analysis can be viewed as random influences.[10] In the light of more recent sociological research,[11] however, it is evident that even these elements of human behaviour are influenced by the social, political, and economic context within which people live. To accept Friedman's view one would have to assume that this context did not change, and that the government did not alter its actions in any way to meet changing environmental, political, economic, social, and cultural conditions. Given the need to take account of this social, political, and economic context and the effects that government action or changing external conditions may or may not have on this context, it seems advisable for the pragmatic manpower forecaster to consider an alternative approach. It is advocated here that he should attempt to identify the adjustment mechanisms underlying trends of growth in the labour force, and validate his analysis by determining, through verbal debate and computer simulation, whether the mechanisms he has identified truly represent adjustment processes occurring in the so-called real world. These adjustment mechanisms will be primarily non-market mechanisms, and will take account of the fact that human actions are not only goal-oriented[12] but are also influenced by the feedback of information from the "real world."

2. The methodological principles adopted in this study

The methodology used in this study is "pragmatic," and it enhances this pragmatism by including some of the non-market adjustment processes that influence the labour market. It focuses on an initial "onlooker forecast," but it also provides a method for testing policy-conditional forecasts. Because the adjustment processes that are identified are of necessity quite simple, the forecast should be viewed as only an indication of the pressures on or the direction of future labour supplies. In other words, these pressures should be viewed as those resulting from the adjustment processes, whether or not other events in fact cause labour supplies in the future to be difference from these forecasts. The validity of the model is thus determined from the ability of these adjustment mechanisms to reproduce "real-world" processes.

A number of statistical analytical techniques are also used in this project. However, these techniques are used only to formulate the assumptions behind the projections of exogenous variables (i.e., those whose variability is not calculated within the model; see Appendix I for a systematic discussion of these variables). The variables that are calculated internally are treated as both dependent and independent. The coefficients relating variables are also treated as interdependent variables.[13]

It may be useful to give an example of a typical series of relations that can be investigated with the methodology used in this study. Suppose that the government has decided to increase its flow of capital into Northwestern Ontario. The immediate

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[10] Ahamad and Blaug, Manpower Forecasting, p. 23.

[11] See, for example, The Report of the Mackenzie Valley Pipeline Inquiry, vol. I, II, Mr. Justice Thomas Berger, Northern Frontier, Northern Homeland, and the work on Social Network Theory by P. Harries-Jones at York University and S. Berkowitz at the University of Toronto.

[12] Economic theory assumes that human behaviour is entirely goal-oriented, and describes it as a maximising of the utility of the products, services or labour purchased within a given budget.

[13] They are not given an exogenously determined variability as they would have been if, for example, fertility rates were assumed to decline by fixed amounts each year.

effects of these expenditures are an expansion of industrial output and an increase in the number of jobs available. Unemployment falls, while per-capita production and the standard of living increase. Despite the economic "take-off" effects[14] of such developments, other adjustment processes may come into play to neutralise these benefits. The higher standard of living encourages migration into the Region, thus increasing the population. An increase in the population engenders rising unemployment and lower per-capita production, particularly because the increase in migration is likely to be delayed and to exceed the expansion of job opportunities. At the same time, the higher standard of living increases demands for leisure time and for a shorter work-week, demands that will counteract any gains in productivity. In addition, despite the historically observable tendency for normal conditions of industrial growth in the Region to promote private capital inflows, the government-induced acceleration in growth may even result in a reduction of such inflows.

All of the effects mentioned above are difficult to predict with traditional statistical analysis. While it may be true that the data can be used to show a correlation between, for example, an inflow of capital and the level of unemployment, these mechanisms are not shown explicitly, and it is virtually impossible to predict what would happen if policy initiatives that change the historical conditions were introduced.

The methodology used here attempts to find and evaluate the mechanisms that link such variables as unemployment and capital inflows. Rather than use a statistical analysis of data in formulating the relations, it uses "expert" or qualitative descriptions of the adjustment mechanisms. This method permits the series of steps in any adjustment mechanism to be stated explicitly rather than as a composite relation. It is particularly useful because it can identify the many adjustment processes that frustrate policy makers by counteracting the effects that had been expected from their policies. The identification of such mechanisms makes it possible to devise policies that can produce more lasting results. For example, if in-migration can neutralise the benefits of capital expansion, then it is necessary to find mechanisms that can prevent the adjustment leading to a delayed net in-migration.[15] If capital expansion leads to demands for more leisure time, then more comfortable working conditions might be introduced to reduce this adjustment; and if such policies lead to a reduction of the inflows of private capital, then the use of incentives to private capital might lessen the effects of lower pressures for further growth.

The mechanisms included in this analysis are first identified through a verbal description of the sequence of steps describing the relationship between one

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[14]The idea of "take-off" effects is that expanded production in one industry will encourage growth in other industries, particularly service industries. These effects will, in turn, encourage further industrial development, and so on.

[15]This might be done by increasing the influence of family, friends, and associated groups, and reducing the influence of economic factors on migration. (See the excellent article on family influences by W. H. C. Simmonds, Through Human Eyes: A New Approach to the Problems of Work-forces in Remote Areas [National Research Council of Canada, 1976].) Such a policy could also influence trends in investment by balancing "industrialisation" pressures with a concern for the relevance of these investments to the unique situation of Northwestern Ontario, and by bearing in mind particularly the need for environmental protection and protection against economic disruption caused by closing down operations.

No such policy initiatives were tested in this project because to have done so would have required a substantial design exercise. To test alternative designs the computer model would have to be altered in accordance with the design being tested. Such an exercise, although relatively simple, was beyond the scope of this study.

variable and the next up to the point where the effects return to the beginning variable. This description is a verbal "algorithm" of an adjustment process, which is then translated into a computer algorithm in a series of equations describing each step needed to calculate each of the variables. For example, the interaction between population levels and production can be shown by the following series of equations:

1. The population in any year equals the population in the previous year plus the number of births minus the number of deaths occurring since that year.

   L1[16]: Population (in time T)[17] = Population (in time T-1) + Births (between T-1 and T)[18] - Deaths (between T-1 and T)

2. A certain number of the population who are of working age belong to the labour force.

   A1[19]: Labour Force = Working-age Population × Participation Rates

3. The labour force produces an amount determined by the productivity of labour.

   A2: Production = Labour Force × Productivity of Labour

4. Production generates a value that is then distributed among the population.

   A3: Per-capita Production = Production ÷ Population

5. The amount of production per person influences the birth and death rates of the population.

   A4[20]: Feedback adjustments are derived from per-capita levels of production compared to 1971

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[16]This is a "level" equation. Such an equation always relates the level of a variable at a given time to its level at a previous time, making appropriate adjustments for gains and losses between time periods. In order to run a simulation using the computer model an initial value is required for the variables given by a level equation.

[17]This is abbreviated as Population (T).

[18]This is abbreviated as Births (T-1).

[19]Any equation that is not a "level" or a "rate" equation is referred to as an "auxilliary" equation.

[20]The steps given so far are purely physical relations. At this point, however, qualitative judgments must be made on the kinds of personal decisions that people make in light of the changes that accompany a rise or fall in production. Thus, there is a "feedback" effect of per-capita production on births and deaths. This feedback effect is shown in a table that includes a "qualitative" description of the adjustments:

Adjustment to the 1971 death rate	+6.0	+2.0	0	-1.0	-1.2
Adjustment to the 1971 birth rate	+2.5	+1.0	0	-1.0	-1.5
Per-capita production compared to 1971	0	+.5	1	+1.5	+2.0

A5[21]: Birth Rate = Birth Rate in 1971 + Adjustment to the Birth Rate from Per-capita Production

A6: Death Rate = Death Rate in 1971 + Adjustment to the Death Rate from Per-capita Production

6. Actual births and deaths are a product of the size of the population and the birth and death rates.

R1[22]: Births (T) = Population (T) × Birth Rate

R2: Deaths (T) = Population (T) × Death Rate

7. As in step 1 for the next year.

L1: Population (T+1) = Population (T) + Births (T) - Deaths (T)

This series of steps is repeated for each year. Because the population is divided into five-year age groups, the yearly updating of the population figures also uses a type of cohort analysis.[23] After reducing the population by the number of deaths in each age group, one fifth of the population in each group is passed into the next age group in each year covered by the analysis. Births are then added to the first group.

This interaction between population and production, which is only one of the three major adjustment mechanisms identified in this analysis, is more complex in the actual model than in the example given above. In the model, the labour force is divided into the four male and female primary and secondary groups, per-capita production is calculated for each of the three production sectors, and the affects of in- and out-migration on the labour force are taken into account.

The qualitative information for the "feedback adjustment from production" was obtained mainly from the work of Forrester and adjusted to reflect the more open economy of Northwestern Ontario. Such factors as the tendency of increasing health services to reduce deaths and the tendency of lower agricultural production to reduce births (i.e., to lower the need for large families) are included. The influence of production on migration is calculated according to the principle of "economic rationality": it is assumed that the economic conditions in different regions determine the decision to migrate.[24] This assumption avoids the more difficult task of taking into account the "subjective" rationales for migrating, i.e., those that the individual

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[21]Variables affected by a feedback adjustment are given a value for one year for which there are data--e.g., 1971--and then calculated each year in the simulation by adjusting this rate according to the effect of the difference between per-capita production in that year and in 1971.

[22]An equation that calculates the amount by which the level variables are adjusted is referred to as a "rate" equation.

[23]This technique was not used by Forrester. It is used here to incorporate in the analysis the effect of the changing age distribution of the population on yearly births and deaths. This technique should not be confused with true cohort analysis, which develops a mathematical formula for calculating population distributions on the basis of past data.

[24]See G. Sabir Shakeel, Why People Move from Northwestern Ontario, Northwestern Ontario Manpower Adjustment Study, no. 9 (1978).

derives from his social, economic, and political situation, or that are guided by the networks of family, friends, and associates within which the individual lives.[25]

A second adjustment mechanism, again based on qualitative information obtained from Forrester, proceeds from the observation that there is a relation between the level of per-capita production and the desire for further growth and, consequently, for additional supplies of labour. It is known that when per-capita levels of production are low the desire for increased production rises, and when per-capita levels are high the desire for increased production diminishes. This mechanism implies that a greater desire for growth results in additional supplies of labour, increased production, and, finally, a reduction of the desire for further growth.

A third adjustment mechanism affects the rates of participation in the labour force. As participation increases, non-participation decreases. When this happens, the continuing requirements of young families for home care and of the population at large for further education tend to counteract increases in the participation rates and thus reduce the effect of production on participation rates. The reduction will be great if non-participation is low, and may disappear completely if non-participation is very high. This adjustment is another of the constraints on economic growth.

The last two adjustment mechanisms are somewhat more complex in the actual model than the outline given above in that they affect not only participation rates but also the employment of the available labour force (i.e., the number of hours each worker spends in productive employment as well as the number of people employed) and the allocation of this employment to the three production sectors.[26]

Each of these mechanisms uses a table that gives a series of values for the feedback adjustments. The values given in these tables are significant only to the extent that they reflect the trend embodied in the qualitative information on the nature of this feedback. The actual feedback relation is far too complex to be described accurately except in qualitative terms, but it is generally known whether this feedback is negative or positive and whether it is increasing or decreasing.[27] The size of the feedback effect is related to the absolute size of the variable adjusted by the feedback effect.[28]

These adjustment mechanisms interlock when they affect the same variable, and cause the calculations to be extremely complex even though the interactions themselves are relatively straightforward. The many thousands of calculations that are required necessitated the use of a computer.

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[25] See P. Harries-Jones, "Methods and Decision Assumptions Made in the Investigations of a Guaranteed Annual Income," paper presented to the Guaranteed Annual Income Conference, Winnipeg, 1976.

[26] In Forrester's work these adjustments affect only employment; the participation rates were assumed to be constant. The present analysis has extended the adjustment process to include a variable participation rate.

[27] It is known, for example, that a greater per-capita volume of goods decreases (and does not increase) birth rates, and that this decrease grows smaller (not larger) as the per-capita volume of goods increases. This observation reflects the fact that industrialisation in any country has always been accompanied by a decline in the birth rate.

[28] For example, birth rates drop as per-capita production increases, but the size of the feedback effect of per-capita production on birth rates will not be so large as to reduce birth rates to zero.

It should be noted, finally, that the assumptions describing each interaction can be changed very simply by using an input programme to the computer simulation model. This system permits the rapid evaluation of the often non-intuitive results of particular policy initiatives. The computer programme is thus a tool created by this project to structure the data for Northwestern Ontario in a way most useful for further policy analysis.

CHAPTER III

RESULTS

Economists have long been concerned about the inability of most traditional responses to economic problems to permanently solve these problems. Although they have often brought about an immediate "boost" in the economy of an area through such policies as increased financial support, they have invariably found that greater and greater support was required to maintain the initial benefits or even to re-establish the conditions that prevailed before such measures were introduced.

The analysis presented in this report shows one of the main reasons for the impermanence of the benefits of most of these policies. Built-in feedback responses and delays generate cycles that continue to operate unless the mechanisms themselves are altered. When many such response-and-delay mechanisms operate simultaneously their effects can be very complex, but they retain their cyclical nature. Furthermore, though some of these cycles may require a long period of time for their fulfillment, they nonetheless have bearing on the immediate future. In other words, the effects of these mechanisms are always present and are partially responsible for either amplifying the consequences of government actions beyond their intended scope or for frustrating them completely.

The five graphs that appear at the end of this chapter (on pages 16 to 20) show "onlooker forecasts" of the growth in the labour force and its three components--the natural increase in the population, changes in the participation rates, and migration--for each of the male and female primary and secondary labour force groups and for the labour force as a whole. Data for the total labour force are given for the years 1961 to 2020 in order to show more clearly the cycles underlying the economic data of the Region.

The male primary labour force began to grow in the late 1960s after having declined for some time before that. This growth was due to an increase in participation rates, a decline in net out-migration, and a growth in the contribution of the natural increase in population. However, declining participation rates, growing out-migration, and a slower growth in the contribution of the natural increase in population during the 1970s should cause the male primary labour force to continue to grow, but at a declining rate, its annual growth dropping from about 700 a year to a little over 300 a year by 1982.

The decrease in the rate of growth in the male secondary labour force began in the late 1960s, and should continue through the 1970s, its growth dropping from about 500 a year in 1971 to a reduction of 100 a year by 1981. The growth in the contribution of the natural increase in population decreases steadily during this time, and the rate of growth in participation rates decreases until it becomes a decline in the participation rates after 1977.

The rate of growth in the female primary labour force also decreases, its rate dropping from 650 a year to 300 a year by 1982. This decrease results from a slower growth in participation rates, which decline after 1981.

An even more sharply decreasing growth in participation rates contributes to a decrease in the rate of growth of the female secondary labour force; the annual growth in this group drops from 1,300 in 1968 to less than 100 by 1981, increasing

after this time as a result of a smaller net out-migration.

The rate of growth of the total labour force is about 2,700 a year in 1970; it drops to zero in 1988, after which it further declines, reaching a rate of loss of over 550 a year by 2020. Although the natural increase in the population continues to contribute a larger and larger number of people to the labour force each year until 1976, this contribution subsequently decreases, becoming zero in the year 2004.

The contribution of participation rates to the rate of growth of the labour force follows a cycle. In 1970 it contributes 1,700 persons a year; its contribution drops to zero in 1977, and to a loss of almost 500 persons a year by 1986. After 1986 the trend reverses, the contribution reaching zero in 2004. After that time the contribution once again begins to grow.

It is rather difficult to explain these trends because they result from the many interacting adjustment processes built into the model. However, there appear to be several dominant adjustment processes. The declining contribution of the natural increase in the population to the labour force is primarily the result of the aging of those persons born during the post-war "baby boom." The growth in per-capita production of goods and services results in higher net in-migration (see Appendix II: Assumptions Made in Building the Model, page 44), but this is more than offset by the higher net out-migration resulting from the decline in per-capita food production. The attraction of job openings, particularly for female primary and secondary workers, which has resulted in an unprecedented increase in participation rates among these groups, is expected to diminish, with the result that slower growth may be expected in participation rates during the 1970s. This trend is due primarily to a greater increase in the demand for non-participation (i.e., for education, home care of families, and increased leisure time) than in the demand for further growth in industrial production and services. The fact that the projected losses from the labour force due to out-migration are greater than the projected gains from the natural increase in the population after 1990 is the major reason for the reversal in the trend of change in participation rates, which again make a positive contribution to the labour force after the year 2000.

This report has projected the effects that some non-market adjustment processes have had and will continue to have on the labour force in Northwestern Ontario. To this end it has employed an unfamiliar methodology whose implications should be kept in mind when interpreting the results. The reader should remember that many adjustment processes have been omitted from the analysis, and that many assumptions were made in defining those processes that were included. Nevertheless, it is clear from the results of the tests of alternative policies (given in Appendix III) that some adjustment processes are highly resistant to change by those methods conventionally adopted to encourage growth in the labour force.

Chart 1

Increase in the Labour Force (Ages 15 to 64) and Its Components
in Northwestern Ontario, 1962 to 2020

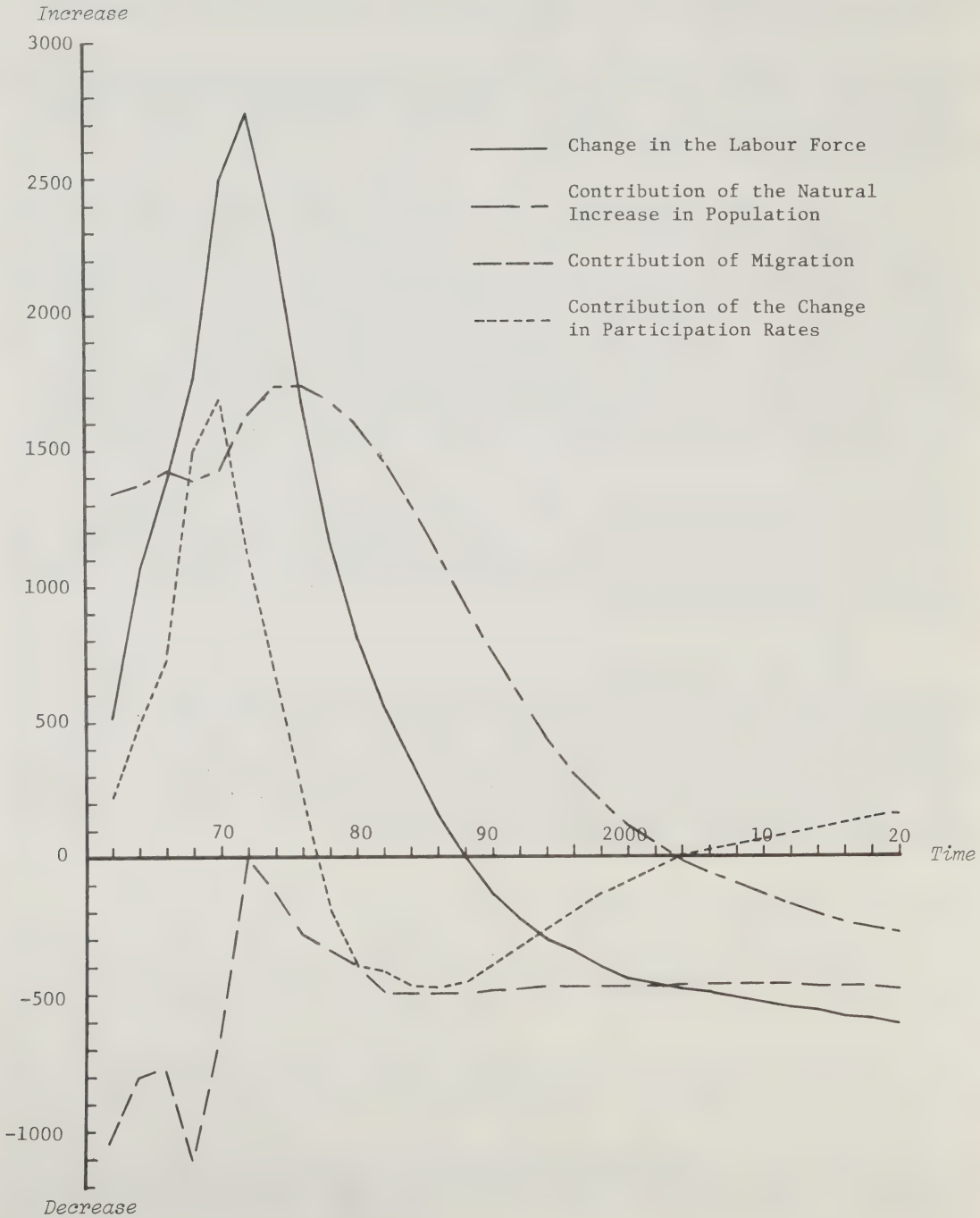


Chart 2

Increase in the Male Primary Labour Force (Ages 25 to 44) and Its Components in Northwestern Ontario, 1963 to 1981

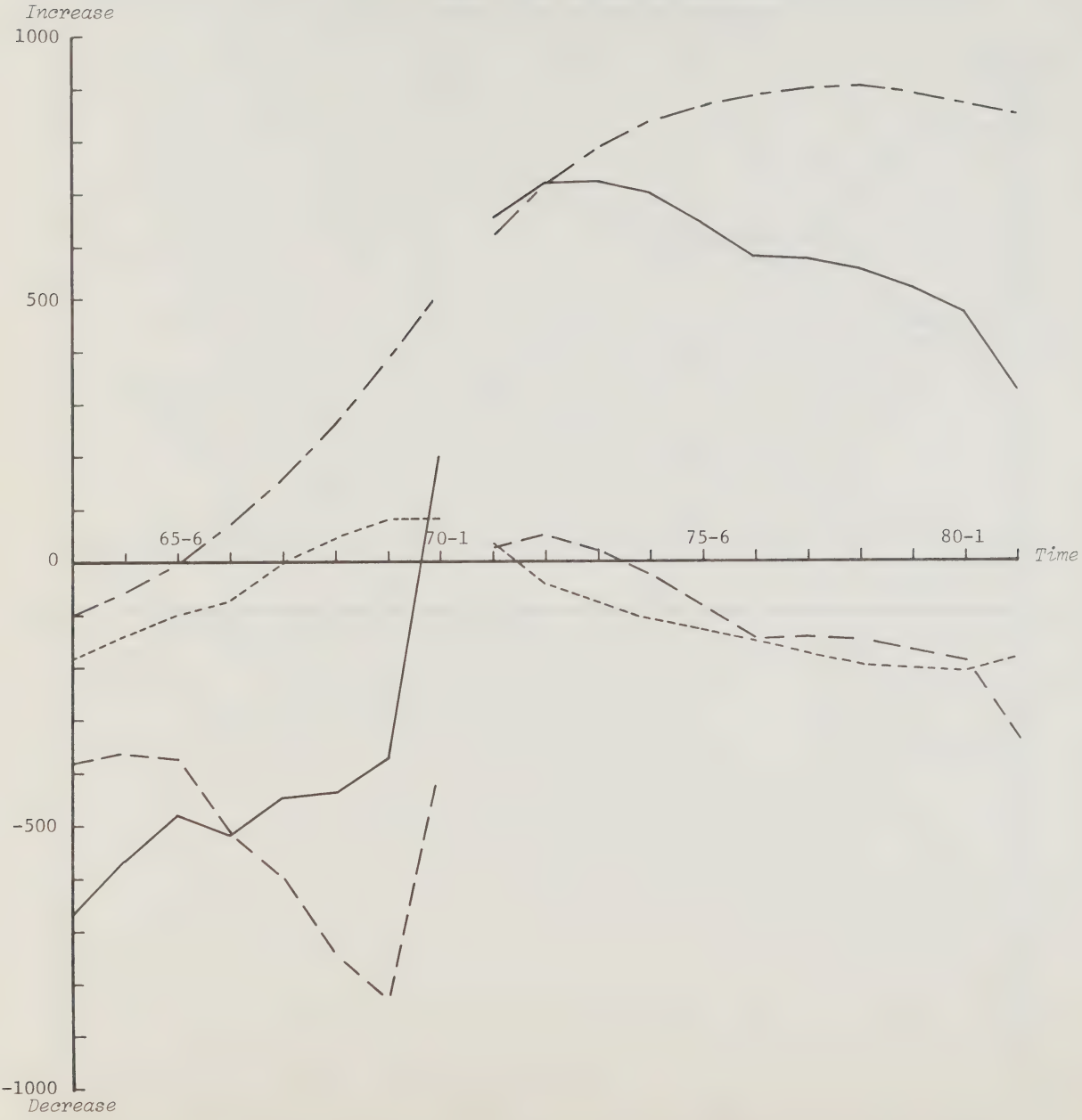


Chart 3

Increase in the Male Secondary Labour Force (Ages 15 to 24 and 45 to 64) and Its Components in Northwestern Ontario, 1963 to 1981

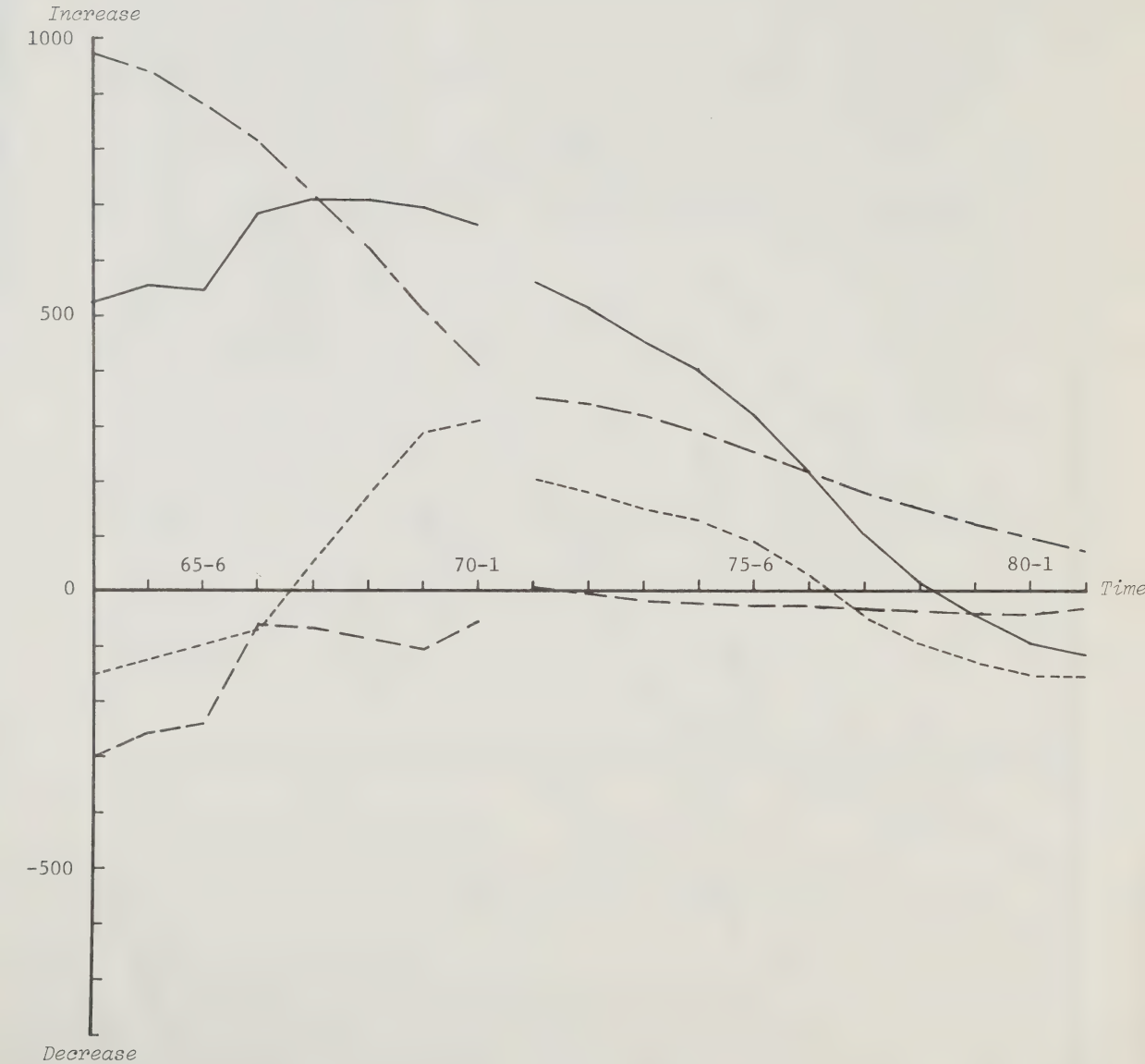


Chart 4

Increase in the Female Primary Labour Force (Ages 25 to 44) and Its Components in Northwestern Ontario, 1963 to 1981

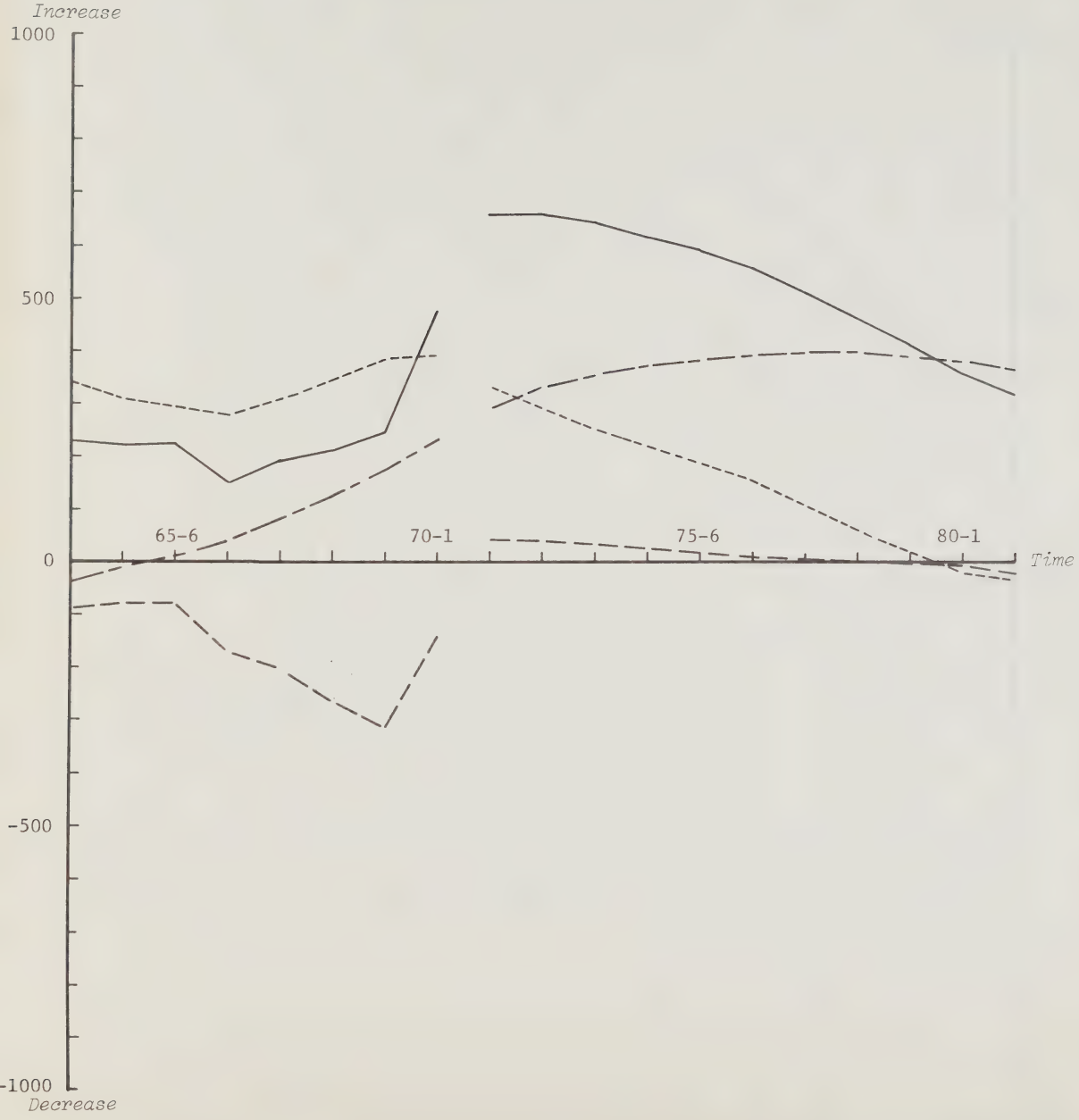
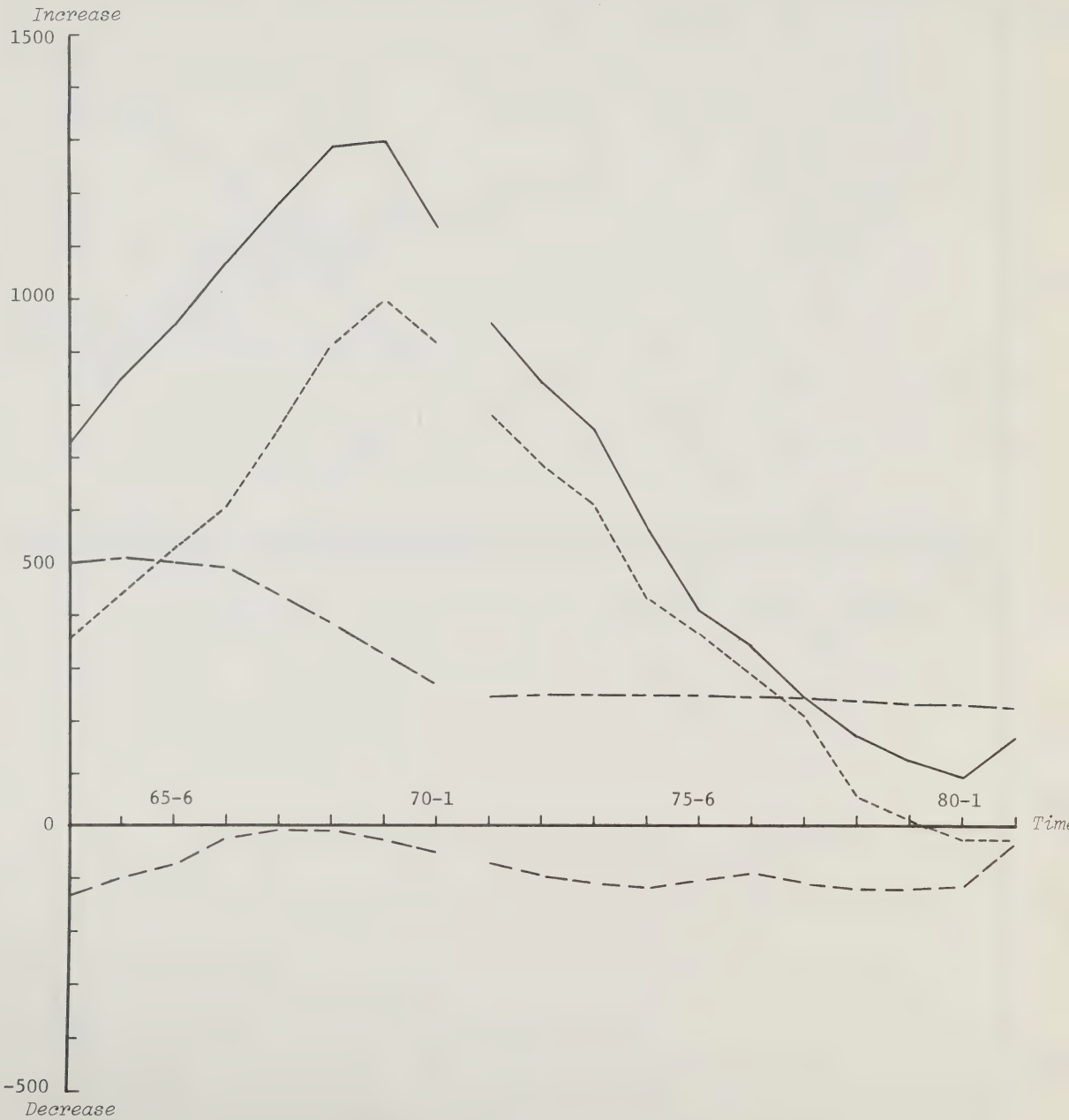


Chart 5

Increase in the Female Secondary Labour Force (Ages 15 to 24 and 45 to 64) and Its Components in Northwestern Ontario, 1963 to 1981



APPENDICES

APPENDIX I

TECHNICAL DISCUSSION OF THE METHODOLOGY

1. The nature of feedback processes

The methodology used in this report is based on the notion of feedback processes. The simple example of a governor on a steam engine demonstrates this notion very clearly. As the pressure in the boiler increases, for whatever reason, the governor spins more rapidly. The centrifugal force generated by the spinning governor causes its attached arms with weighted balls at the ends to fly outward. These arms are connected to a regulator that shuts off the supply of fuel as they fly outward and increases the supply of fuel as they fall inward. As the pressure increases, the fuel supply is diminished, lowering the boiler pressure, and as the pressure decreases, the fuel supply is increased, raising the pressure.

This is an example of a feedback process, and it illustrates several important characteristics of such processes. First, the variable whose constancy is desired--the boiler pressure--is continuously monitored by a device connected to a source of this pressure--the fuel supply. Second, there is no need to know the causes or possible amounts of variation in the boiler pressure; the governor will always compensate, within technological limits, by adjusting the fuel supply. Third, the system (i.e., the feedback process) is designed so that, regardless of external influences, it will adjust itself to counteract these variations. Finally, there is a characteristic oscillating behaviour in this system as boiler pressure varies between certain limits according to the linkages and delays in the system.

This example can be usefully extended to include human beings. If, instead of a mechanical governor, the system uses an engineer who watches the pressure dials and who instructs a fireman to either increase or decrease the amount of fuel to the fire, the pattern is much the same. Whether the boiler is driving the train uphill or downhill, at high or low altitudes, on rich or diluted fuel, the boiler pressure can be held almost constant, again within technological limits, without knowing the causes of variation in the pressure, without predicting these changes, and without knowing the amount of compensation required for particular causes of variation.

Although the linkages and delays are somewhat different here than in the case of the purely mechanical governor,[1] the basic pattern of behaviour, in which boiler pressure oscillates about a desired level, will be essentially the same. If the system is extended further to include an inventory of coal, then some knowledge of the possible variations giving rise to different volumes of coal consumption is of course needed. The system will differ according to the basis on which the decision is made to order additional coal, but it will still have a characteristic behaviour pattern that will be retained in spite of any changes that may occur in the external conditions. The pattern will be different from that of the example above because

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[1] In particular, there is more than just a channel of communication and appropriate messages, as in the case of the mechanical governor; people's awareness of other people in the process constitutes part of the context within which the elements of this feedback process interact. However, this aspect of a feedback process is excluded from the example described here in order to investigate other aspects more thoroughly.

there are now two feedback processes: one controlling the pressure in the boiler, and another controlling the inventory of fuel.

Stafford Beer, a British cybernetician and business consultant, has noted that social institutions are organised so that information feedback generates internal responses that hold key variables constant despite many variations in external conditions and consequent changes in "other" internal variables or transactions.[2] This pattern does not prevent the organisation from adopting an alternative set of values or key variables. In the example given above the engineer and the fireman might have decided to maintain constant speed rather than constant boiler pressure, or even to maintain an ever-greater acceleration, a pattern very similar to the growth strategies of many organisations.

The purpose of this extended example is to demonstrate the key concept of the methodology used in this study: that there are information feedback processes in society that are structurally determined by institutions, organisations, culture, tradition, training, etc., and that the essential effects of these processes endure despite many external variations as long as the structure of these processes is not altered. It is not by changing attitudes or by providing greater quantities of certain factors, but only by redesigning the social, institutional, organisational, and other structures that the fundamental dynamic of such a system can be changed. The changing of attitudes or variable quantities within given structures is likely only to generate internal pressures that will give rise to compensating actions that return the system to its original set of values. Such a redesign occurs most often in our present society within institutions and organisations in order to compensate for external variations and to maintain stable relations with other organisations. Thus, the system maintains itself against external influences.

This is to a great extent the issue to which J. Forrester addresses himself. His technique of Systems Dynamics is one way of describing such feedback processes in order to study their fundamental dynamic, especially when they are redesigned. Such a redesign may mean--to return to the earlier example--introducing a new basis for reordering supplies, or it may mean introducing an entirely new feedback system that contains the other feedback processes within it.

The value of Systems Dynamics is that it organises the knowledge of societal processes and the feedback contained in them in such a way as to permit the testing of alternative designs of the feedback processes and to indicate factors that are most likely to produce a new dynamic if redesigned. Because such factors are only elements of the system's structure it is unlikely that the new dynamic can be predicted intuitively. Instead, they can be discovered only through experimentation with the model.

2. The description of a feedback process

In order to describe a feedback process so that it can be "computed" by electronic means, the verbal description of this process must be translated into a series of equations for calculating the size or amount of the different elements in the process. In Systems Dynamics this translation is carried out by using the concepts of "levels" and "rates."[3] One can describe a certain element in a process--

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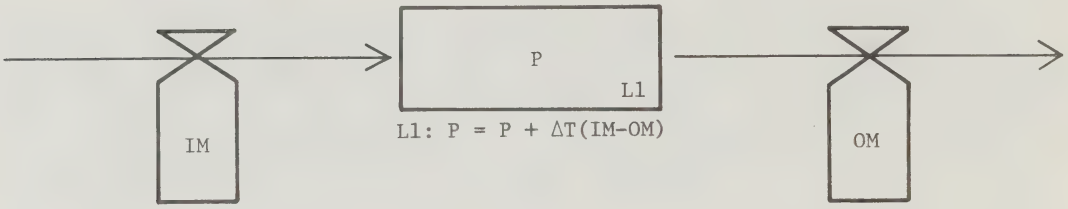
[2] Stafford Beer, Platform for Change (London: John Wiley & Sons, 1975), p. 146.

[3] These concepts are borrowed from hydrodynamics, in which a reservoir has a level of liquid in it and valves which control the rate of flow of the liquid into and out of the reservoir.

population, for example--by reference to its size at a previous time, plus new additions, minus losses. In other words, the "level" of the population variable equals its previous value plus the "rate" of growth (or inflow) multiplied by the length of time since the last calculation, minus the "rate" of loss (or outflow) multiplied by the length of time since the last calculation. This equation is shown schematically in Diagram 1.[4]

Diagram 1

Description of a Process Without Feedback



P = Population
IM = Rate of In-Migration
OM = Rate of Out-Migration

The feedback is then described by means of a pressure table,[5] which shows a relation between, in this case, population and migration. If the population is engaged in productive activity the per-capita production may influence the rates of in- and out-migration. This relation is assigned a referential value using the data for any one year, so that for the given per-capita production in that year migration rates are also given. These are called the "normal" values. Any deviation from this "normal" per-capita production will then increase or decrease migration rates from their "normal" values. The amount of the increase or decrease in these "normal" migration rates can be given as a table for each amount of deviation from the "normal" per-capita production. This relation is shown schematically in Diagram 2 (page 25).

The per-capita production can be calculated from the level of the population and from the exogenous factors of participation in the labour force, unemployment, and productivity. A comparison of this to the "normal" per-capita production gives the ratio of per-capita production to the "normal" per-capita production, PCP.

The pressure on, or the adjustment to, "normal" migration rates is then obtained from a table. At a PCP of 1 (i.e., at a per-capita production equal to the "normal" per-capita production) the pressure is zero. (Note that POI is given as a

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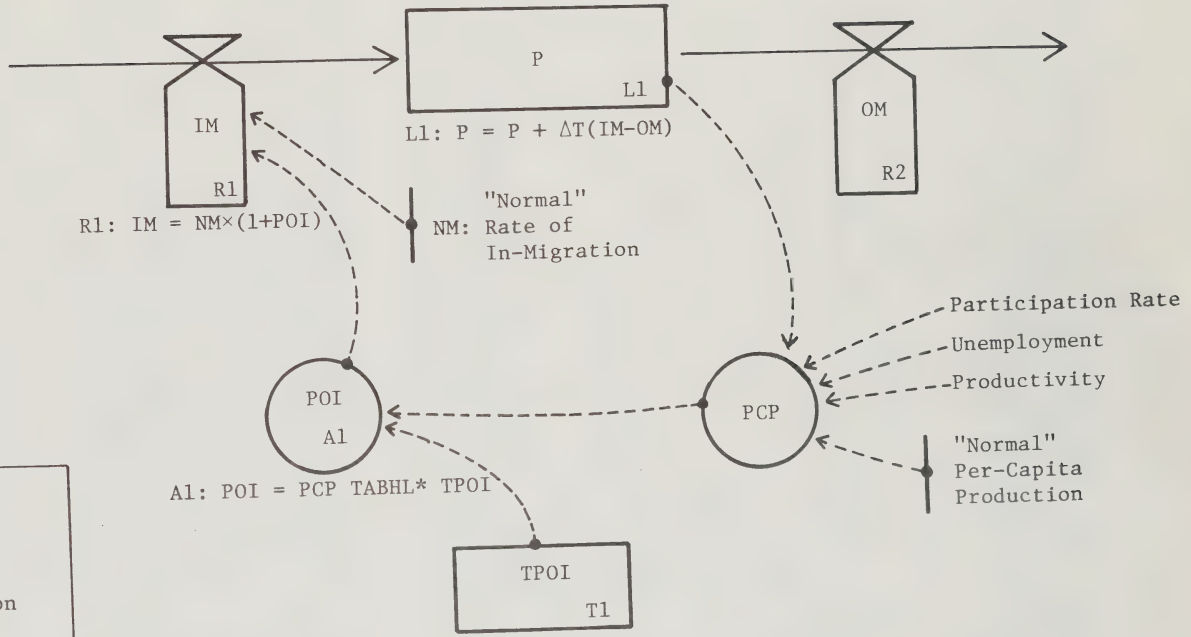
[4]The symbols used in these diagrams are taken from Forrester, Economic Development.

[5]The concept of the pressure table was developed by Forrester; see Economic Development.

Diagram 2

Description of a Process With Feedback



POI	-1	-.35	0	.2	.3
PCP	0	.5	1	1.5	2

PCP = Ratio of Per-Capita Production to "Normal" Production

POI = Pressure on In-Migration

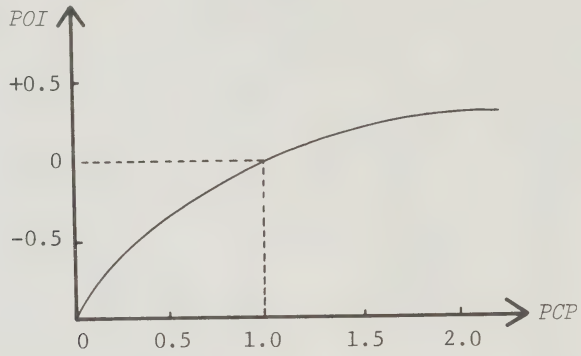
TPOI = Table of Pressure on In-Migration for Each Level of Per-Capita Production

*TABHL is a computer sub-programme that interpolates the value of POI for given PCP from the table TPOI.

percentage adjustment to "normal" migration.) The rest of this table shows other intuitively known adjustments. At a PCP of 0 there is unlikely to be any in-migration; the pressure, therefore, is -1. The other points in the table reflect the fact that as PCP rises the increase in the in-migration rate is likely to be rapid at first, becoming less pronounced as the PCP rises above 1. This trend is shown in Diagram 3.

Diagram 3

The Relation Between Pressure on In-Migration and Per-Capita Production



The actual values in this table are not important as long as at a PCP of 1 the POI is equal to zero and the shape of the graph reflects an understanding of the feedback relation. The shape of this graph gives the values in the table, and constitutes the information contained in the model that requires the most careful evaluation. The shape of the graph cannot be ascertained merely from an empirical analysis of the data, which have resulted from many such interacting feedback processes.

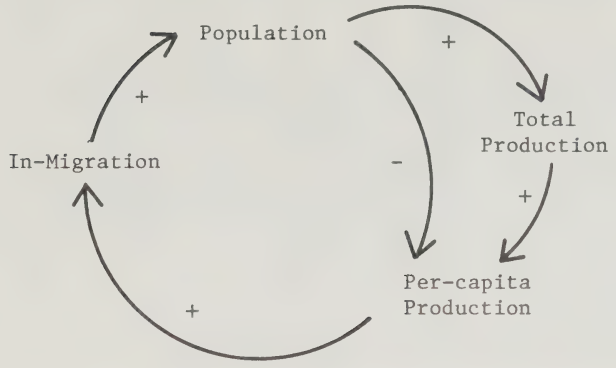
The feedback relation is completed by calculating the rate of in-migration for a given year as the product of the "normal" rate and the pressure on in-migration. Thus, at a PCP of .5 (i.e., half the "normal" value), in-migration will be 1 - .35, or .65 of its normal level. This in-migration affects the level of the population, which in turn alters per-capita production and the pressure on in-migration.

The structure of the model (i.e., the feedback loops) can be established in the manner described above. The actual dynamic of the model can be studied with data (either actual or arbitrarily selected) on initial values, normal values, the values of exogenous variables, and the pressure table. This dynamic depends primarily on whether the feedback loops are positive or negative. In the example given above there are two loops, shown schematically in Diagram 4 (page 27). As population increases, total production increases, thus causing per-capita production to increase. As per-capita production increases, in-migration also increases, thus causing population to increase. If this were the only feedback loop, population would evidence a growth "time-path" (see Diagram 5, page 28). However, an increase in the population decreases per-capita production. This feedback loop from population, per-capita production, and in-migration to population contains an odd number of negative relations and is therefore a negative loop. The result is a self-correcting "time-path" for population (see Diagram 6, page 28). The combined effects of the two loops produce a characteristic constrained growth "time-path" (see Diagram 7, page 28).

The dynamic effect of the feedback processes can be studied by describing

Diagram 4

Feedback Loops Affecting Population
Through In-Migration



the "real world" by means of many such interlocking feedback loops. Whether or not this description is complete, if these feedback processes actually occur their dynamic effects will be present as underlying pressures in the data of future development. Any attempt to change these data would then be frustrated by these underlying pressures unless the structure of these feedback processes is also changed.

3. A brief description of the model

The Labour Force Model presented here is based on the work of N. Forrester.[6] In his opening remarks, Forrester says:

> The model presented here is designed to help explain the dynamics of stagnation in industrial economies, how pressures latent in the growth phase can emerge later to suppress growth. The model serves as a laboratory to test the impact of various policies on the life cycle of development . . . The model deals with the shifting allocation of labour and capital between major production sectors to balance the needs of the population during [this] life cycle of development.[7]

Although Forrester's model is designed to study the complete "life cycle" of an industrial economy, the principles of latent pressure that emerges only at a later time and of the shifting allocation of resources depending on the stage of development hold true even if only part of this life cycle is studied. The Labour Force Model reveals the patterns of labour supply that are created by the dynamics of a number of feedback processes. It is a "collapsed" version of the Forrester model using exogenous variables that are given predetermined values for each year of the forecast period. This procedure avoids many of the complex interrelationships in the economic sector of the Forrester model and permits concentration on the demographic and labour

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[6] See his Economic Development.

[7] Ibid., pp. vii, 1.

Diagram 5

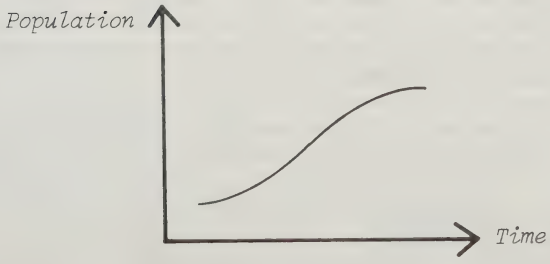
Positive Feedback (Growth)

Diagram 6

Negative Feedback (Self-Correcting)

Diagram 7

Combined Positive and Negative Feedbacks
(Constrained Growth)



supply sectors. These sectors are an expanded version of those given in the Forrester model, and are designed to a) treat births and deaths separately, b) include five-year age and sex distributions of the population, c) account for migration and capital flows in the "open" economy of Northwestern Ontario, d) distinguish between male and female primary and secondary labour force groups, and e) include variable rates of participation in the labour force, influenced by their own feedback processes for each labour force group.

The two sectors of the model are shown schematically in Diagram 8 (page 30). The population sector calculates population from births, deaths, in-migration, and out-migration. Each of these factors is influenced by the pressures of per-capita production in food, goods, and services. The values for these three production sectors are calculated in the labour supply sector from the size of the labour force (obtained from population and participation rates) and its allocation to the production sectors. The actual activity in each production sector, in relation to the desired activity, also exerts pressures on the participation rates and on the allocation of the labour force. The rates of participation and the allocation of labour are prevented from being wholly responsive to the demands of production by interacting with their opposites: the desire for non-participation and the desire for non-allocation (i.e., the desire for time to be spent outside productive activity).

Initial figures are required for population (including its distributions by age and sex), participation rates, and the allocation of labour. The values used in this study are the 1961 data from the Statistics Canada Census and Labour Force Survey. Feedback pressure tables are developed for the relations between per-capita production in each of the three production sectors and births, deaths, in-migration, and out-migration; "normal" values for these last four variables by age and sex are also required. Data for 1971 were used because extensive census information was available for that year. The age and sex distributions of feedback pressures are given as exogenous tables for each time period between 1961, 1966, 1971, 1976, and 1981. To obtain an age and sex distribution of the pressures affecting births and deaths, in-between years are interpolated from the values given in the tables. The distributions of migration are five-year averages; 1961 values are therefore used for 1961 to 1965, etc.

The calculation of per-capita production levels requires "normal" productivity levels (again for 1971) and exogenous tables giving the percentage of this "normal" productivity for the years 1961, 1966, 1971, 1976, and 1981; the in-between years are again interpolated. Feedback pressure tables are developed giving an index (on a scale of 0 to 10) of the desire for further growth at different values of per-capita production.[8] This index is compared with similar indices obtained from feedback pressure tables relating non-productive time to the desire for further non-productive time and participation rates to the desire for lower participation rates. The comparison of the two indices in each case is then used to calculate the pressure on the changing allocation of labour and changing participation rates. Exogenous delays must be known in order to calculate the amount of pressure that will bear on labour allocation and participation rates in each year. Because participation rates are calculated separately for each of the male and female primary and secondary labour force groups, exogenous tables are also required to distribute the index of the desire for further growth in each production sector to these four groups. These exogenous tables are given for the years 1961, 1971, and 1981, and in-between years are interpolated.

The Forrester model was programmed with a specialised computer language called DYNAMO. In order to make it easier to enter the required data and to run a

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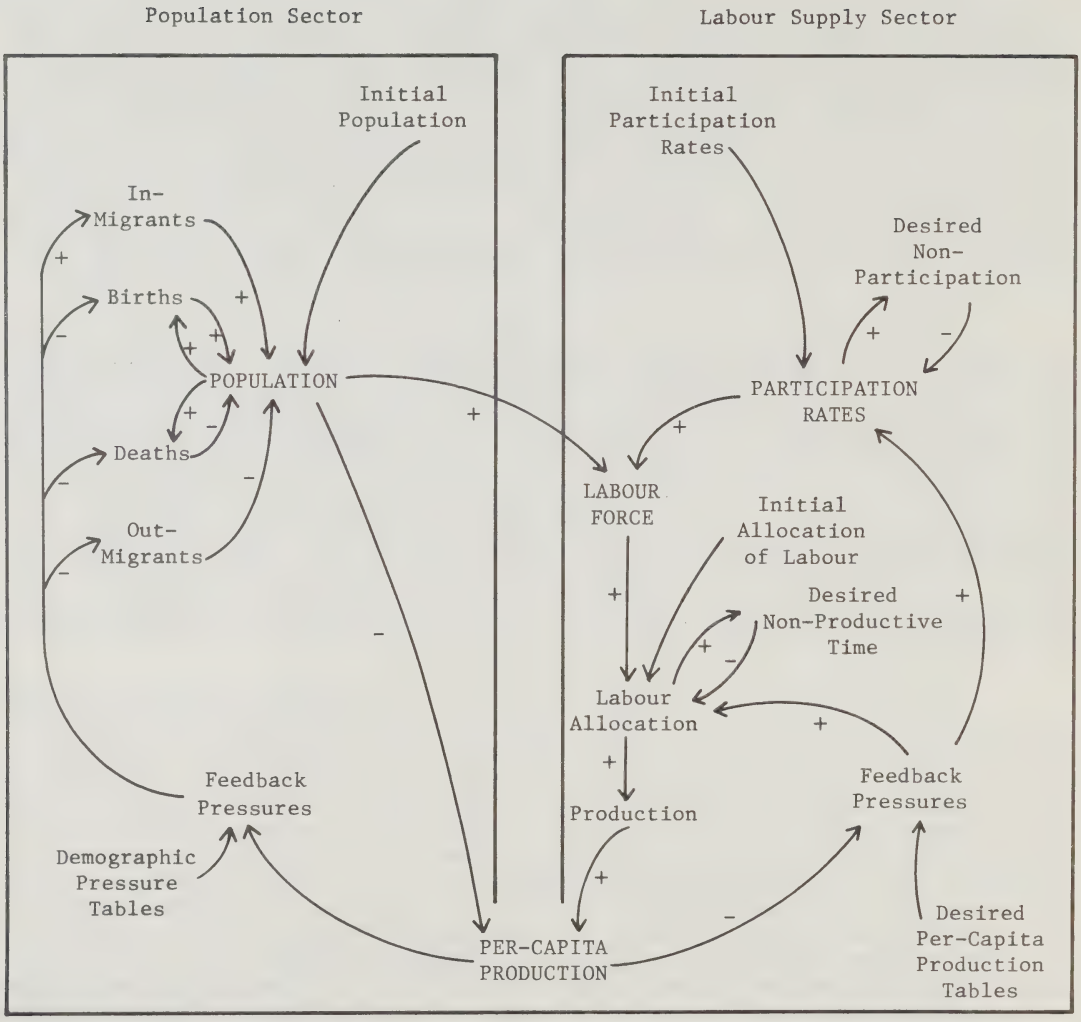
[8] It is possible to give different feedback pressure tables for different years.

Diagram 8

Structure of the Labour Force Model



simulation exercise through a computer terminal, the Labour Force Model has been programmed in APL. The use of this programming language made it possible to develop a number of specialised "systems" routines that enable the Labour Force Model to interact fully with the user, guiding him in using the model and asking for all the data necessary to perform a simulation experiment. The only technical knowledge the user needs is how to "sign on." The user can then work with the data that have previously been stored, he can change the data for a particular simulation experiment, or he can create a new set of data. The data files can also store a brief description of the assumptions underlying the data. The user can select the number of years over which the simulation is to be run, the output variables he wishes to see, and the years for which the output data are to be printed. Finally, the output can be directed to the terminal or to the central computer facility for printing on a high-speed line printer.

4. The structure of the model

Forty-three feedback processes are included in this model. Each can be described with reference to its direction (positive or negative), its shape (increasing, decreasing, etc.), and, when feedbacks affect the same variable, its importance in relation to others. The dynamics of this model are also influenced by time-related exogenous variables. (See Appendix II for details of the values used in the feedback tables.)

4. A. Feedback processes in the population sector

There are 26 feedback processes affecting population (see Diagram 9, page 32). The four feedback relations between production and births, deaths, in-migration, and out-migration from each of the three production sectors give twelve relations between production and population. These relations can be part of either the direct feedback loop between population and per-capita production (1 to 12) or the indirect loop between population, the labour force, and per-capita production (13 to 24). Births and deaths are each part of a feedback loop with population (25 and 26).

Feedback loops 1 to 12 all contain the negative relation between population and per-capita production shown by the identity

$$\text{Per-capita Production} = \frac{\text{Production}}{\text{Population}}$$

However, because the capital stock of goods produced is durable and provides services (or value) to the population over a period of several years, the identity used is

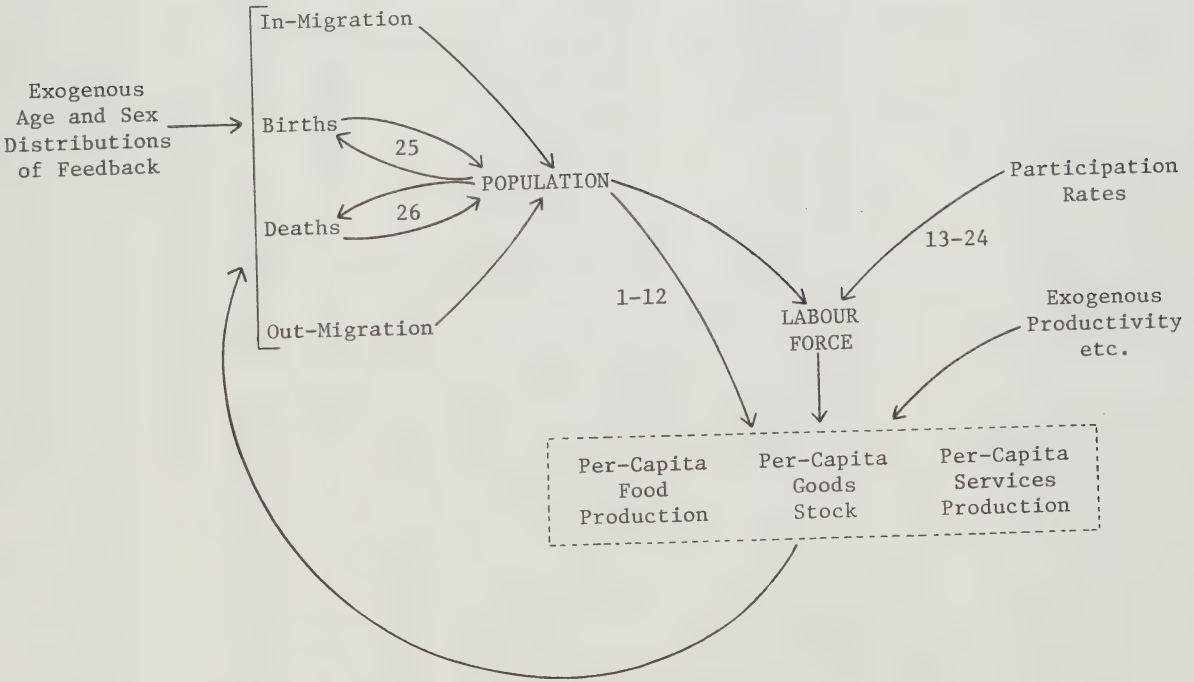
$$\text{Per-capita Goods} = \frac{\text{Goods Stock}}{\text{Population}}$$

The combination of in-migration and out-migration yields a net migration that is positively sloped; in other words, there is greater net in-migration at higher per-capita levels of production or goods stock. Food production has its greatest effect close to 1971 per-capita values, the production of goods and services having a greater effect at both high and low per-capita values. Food production has a positive effect on net births (i.e., net births increase as per-capita food production increases) except at low per-capita levels, where reducing the per-capita production of food increases net births. Goods and services have a negative effect on net births, each having approximately equal weight.

The direction of loops 1 to 12 is reversed in loops 13 to 24. The relative effects of loops 13 to 24 and loops 1 to 12 is determined by the product of participation rates (determined in the labour supply sector) and the exogenous productivity

Diagram 9

Feedback Processes Affecting Population



levels.

Births and deaths are represented by simple loops that are positive and negative, respectively. Births increase as population increases, and thus add further to the population. Deaths also increase as the population increases, and cause a reduction in the population.

4. B. Feedback processes in the labour supply sector

There are 17 feedback processes affecting the labour force, in addition to loops 13 to 24, which also affect the population. Each of the three production sectors has a feedback relation with each of the male and female primary and secondary labour force groups, so that there are 12 feedback loops, 27 to 38 (see Diagram 10, page 34). The three production sectors also affect the allocation of labour, creating loops 39 to 41. Participation rates and the allocation of labour are each a part of loops formed with the desire for their opposite, creating loops 42 and 43.

An increase in the rates of participation increases the labour force, as may be seen in the equation

$$\text{Labour Force} = \text{Population} \times \text{Participation Rates}$$

A larger labour force increases the allocation of labour (calculated in hours) according to unemployment and the length of the workday, and an increase in the allocation of labour raises production according to productivity and capital availability.

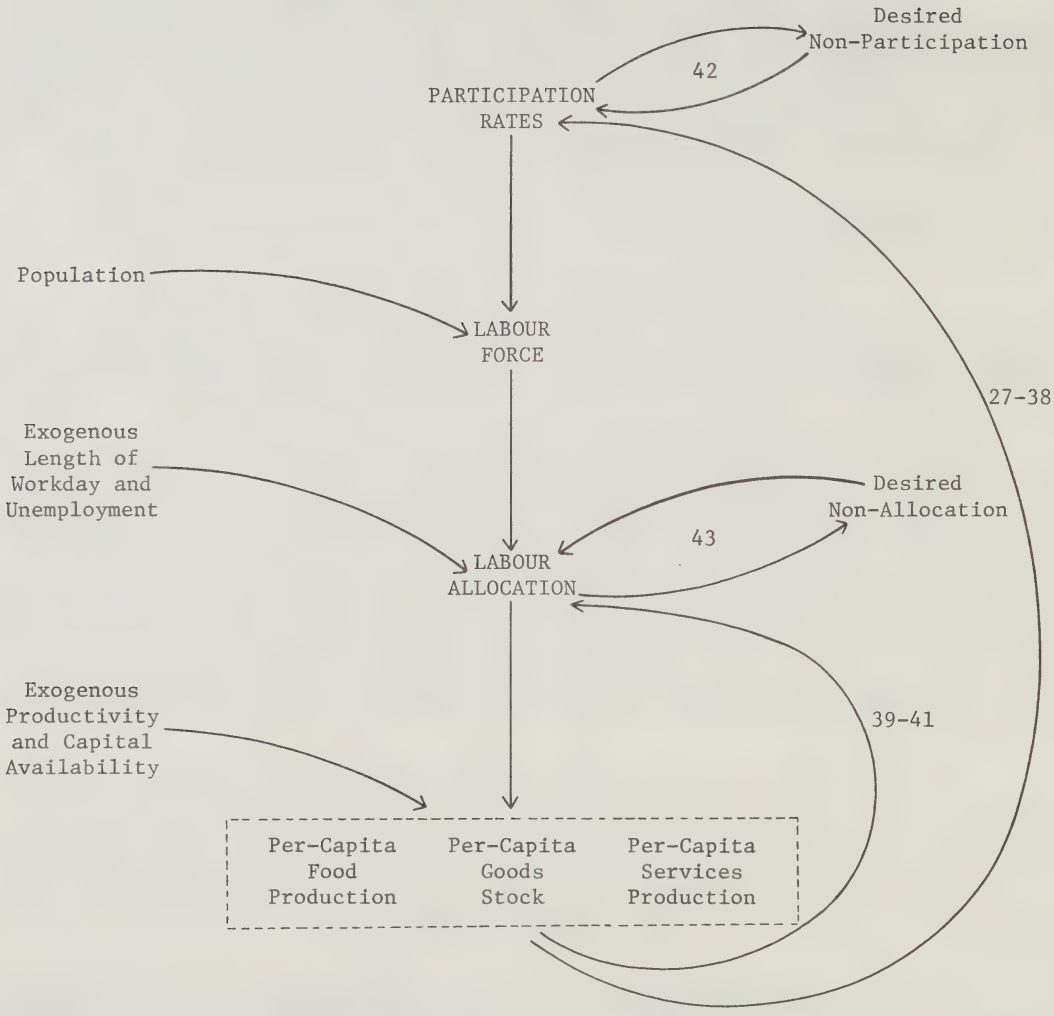
As per-capita production in any of the production sectors increases, the desire for further growth of output from that sector decreases. The services sector has the highest desired growth, the goods-production sector the second highest, and the food-production sector the lowest. This desire for further growth is multiplied by the number of persons in the labour force in each sector to obtain the desired labour supply. Multiplying this desired labour supply in each sector by the exogenous percentages of labour required by that sector from each of the labour force age and sex groups and dividing by population gives the desired participation rates for each sector. There is thus a negative relation between production and participation rates. The results for each sector are added together and divided by the desired non-participation in each labour force group to obtain the desired adjustment to the participation rates.

When participation rates and per-capita production are low the desired adjustment can be as high as 16 times current values. If there is a time delay in making this adjustment of, for example, 25 years, then the maximum upward adjustment to the participation rates in any year is 0.6 times current levels. When participation rates and per-capita production are high the desired downward adjustment can be as large as 0.95 of current values, giving a maximum negative adjustment to participation rates in any year of 0.04 times current levels.

To obtain the allocation of the available labour supplies to each sector in hours, the desired growth is divided by the desired non-productive time; the result is the desired increase or decrease in the existing labour time allocated to each sector. The desired increase can be as high as 16 times the current allocation of labour in any sector when per-capita output is low and non-productive time high. The desired decrease in the allocation of labour can be as great as 0.95 of the current allocation when per-capita output is high and non-productive time low. Adjustment delays for labour moving into or out of each sector are between four and five years. There is thus a maximum desired upward adjustment in any year of three times current levels and a maximum desired downward adjustment in any year of 0.2 times current levels. The actual adjustment to the allocation of labour will depend on the available labour time and the relative size of desired adjustments for each sector.

Diagram 10

Feedback Processes Affecting the Labour Force



It is clear from the figures presented above that the potential increase in the participation rates or the allocation of labour is greater than the potential decrease in any one year. This generates a "ratchet" effect in the adjustments over time: it takes much longer to reduce participation rates and the allocation of labour by a given amount than to increase them by the same amount.

5. Conclusion

The methodology of feedback analysis described above is used to determine the structure of social processes. The use of historical data provides initial values for the simulation exercise, "normal" values for calibrating and simplifying internal calculations, exogenous tables of those variables that are included in the structure but not derived within it, and qualitative information for deciding the values to be entered into the feedback tables. The structure itself is derived neither from a statistical analysis of this historical data nor from the economic theory of price adjustments.

By making this structure explicit in the simulation model the adaptability of the feedback processes in adjusting themselves to variations in external conditions and in maintaining their principal effects in the social system can be determined. The reader should note, however, that although this methodology may be a significant advance in the ability to study the structure of social processes, many questions about the advantages and disadvantages of this approach remain unanswered. The methodology used here does not account for the fact that social systems contain hierarchies of authority, nor does it permit the analysis of such social activities as the ordering of priorities and the altering of objectives by people in the social system. In certain respects, then, this methodology is "static" even though it has been designed to mirror many aspects of the dynamic behaviour of social systems.

APPENDIX II

ASSUMPTIONS MADE IN BUILDING THE MODEL

The methodology used in this project is unique in that it forces the researcher to state explicitly assumptions that would only be implicit in studies using other methodologies. Indeed, the structure of this model is itself an assumption: the feedback processes that have been included and the way in which they operate are derived from "expert opinion." The design of the model may be summarised as follows: Population, participation rates, and the allocation of the labour force to the three production sectors determine the levels of production for each sector. Production and population determine per-capita production. These per-capita values influence the birth rate, the death rate, in-migration, and out-migration, the figures for which are then used to update the figures for the population. They also influence participation rates and the allocation of the labour force to the three production sectors. Births and deaths are a product of birth and death rates and of the level of the population, including its age and sex distributions. Participation rates and the allocation of the labour force to productive activities in the three sectors are limited by desired non-participation and desired non-productive time.

The assumptions used to obtain the data for this model can be divided into four categories: 1) initial values for starting the simulation run, 2) normal values for calculating variables affected by feedback pressures, 3) the feedback pressure tables, and 4) exogenous values.

1. Initial values

Initial values are required for the population, rates of participation, the allocation of labour, and the stock of goods. The population figures for Northwestern Ontario as a whole are given in Table 1 (page 37). Data on the labour force were not available by age group for 1961. The rates of participation were therefore assumed to be as follows: Male participation rates dropped from .877 to .839 between 1961 and 1971. This change is assumed to have resulted almost entirely from a drop in the primary male participation rates[1] (see Table 2, page 38). Female participation rates increased from .302 to .430 between 1961 and 1971. This increase is assumed to be almost evenly distributed between the primary and secondary age groups (see Table 3, page 38).

The initial allocation of labour is obtained from the man-days worked in each production sector in 1961 and an assumed number of hours in the workday in each sector (see Table 4, page 38).

The initial stock of goods was not known. In the model this stock is calculated from the 1961 level of goods production by assuming that goods have an average lifetime of five years, and that the stock of goods grows at an initial rate of 5 percent a year. Because all per-capita levels are "normalised" to 1 in 1971 (see Appendix I), the "normalised" production of food and services in 1971 is given an index value equal to the population in that year. The stock of goods can also be nor-

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[1] The separate participation rates for male and female primary and secondary age groups in 1961 are unknown.

Table 1

The Population of Northwestern Ontario in 1961 by Five-Year Age Groups

Age	0	1-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75 +	Total
Males																		
Number	3,170	11,191	13,234	11,522	7,833	6,984	7,661	8,473	8,147	7,022	6,695	5,555	4,490	3,982	2,839	2,298	2,612	114208
Percentage	.01464	.05168	.06112	.05321	.03618	.03225	.03538	.03913	.03763	.03243	.03092	.02565	.02305	.01839	.01311	.01061	.01206	.52744
Females																		
Number	3,011	10,750	12,374	10,955	7,696	6,552	6,728	7,011	7,640	6,642	5,823	4,604	3,506	2,755	2,249	1,945	2,074	102315
Percentage	.01391	.04965	.05715	.05059	.03554	.03026	.03107	.03238	.03528	.03068	.02693	.02126	.01619	.01272	.01039	.00898	.00958	.47256

Source: Statistics Canada, 1961 Census.

Table 2

Male Participation Rates in Northwestern Ontario, 1961 and 1971

	1961	1971*
Primary	.97	.941
Secondary	.79	.776
Total*	.877	.839

Table 3

Female Participation Rates in Northwestern Ontario, 1961 and 1971

	1961	1971*
Primary	.3	.429
Secondary	.3	.431
Total*	.302	.430

Table 4

Initial Allocation of Labour in Northwestern Ontario, 1961

	Man-Days**	Hours/Day	Hours	% of Total Hours
Labour in Food	2,711	8	21,688	.01214
Labour in Goods	28,469	5	142,345	.07969
Labour in Services	43,250	4	173,000	.09685
Total	74,430	24	337,033	----
Non-Productive Time	----	--	----	.81132

*Statistics Canada, Labour Force Survey, 1961 and 1971 (Microfilm).

**Statistics Canada, Census Data, 1961.

malised in this way, though this method does not give the index value of normalised production. Consequently, several adjustment times were tried for labour moving in and out of goods production until an adjustment time was found that resulted in a per-capita production of goods of 1 in 1971. The level of production in 1961 was about half that of 1971, a proportion that corresponds roughly to that between the value of shipments in mining and manufacturing for 1961 ($340,429,000) and 1971 ($610,007,000).

2. Normal values

"Normal" values were required for birth and death rates, migration, and productivity. These variables were assigned the values they had in Northwestern Ontario in 1971.

The birth rates are the age-specific fertility rates for females 15 to 50 years old distributed to five-year age groups (see Table 5, page 40). The death rates are the age-specific mortality rates distributed to five-year age groups. The infant mortality rate was used for age 0; the rate for the 1-to-4 age group was calculated from census population and mortality rates for the 0-to-4 age group (see Table 6, page 40).

In-migrants and out-migrants for the year 1971 were calculated from Statistics Canada, Special Tabulations, Taxation Data. Because figures for migrants between particular localities that were less than five were not printed except in the total, the printed figures were aggregated to the age groups 0 to 14, 15 to 24, 25 to 44, 45 to 64, and 65+, and differences in the totals were allocated to these groups in the same proportion as the amounts in each age group (see Tables 7 and 8, page 41).

The "normal" labour productivity is calibrated so that under 1971 conditions the per-capita production is equal to 1 (except in the goods sector; see above, page 36). Thus, the "normal" productivity is found by dividing the 1971 population (224,370) by the number of man-days worked in each sector. The number of man-days worked in the food sector in 1971 is 1,450; the "normal" productivity is therefore 154.74. The number of man-days worked in the services sector in 1971 is 50,295; the "normal" productivity is 4.46. The "normal" productivity in the goods sector was calculated to be 2.0.

3. Feedback pressure tables

The feedback pressure tables relating per-capita food, goods, and services to birth and death rates, in-migration, and out-migration have a pressure variable equal to zero at a per-capita level of 1, because under "normal" conditions there are no adjustment pressures. The shape of the feedback relation and the relative importance of the three sectors is assumed intuitively.

Pressure on births by food production is assumed to be positive at low per-capita levels because it has been observed that production at low levels occurs on family farms with large families. The positive effect is not high enough, however, that it cannot be offset by rising per-capita goods and services, which can be exchanged for food. This positive effect drops as per-capita food production increases, and rises again when per-capita production is large, again reflecting the higher birth rate of farming families. Goods and services are both in negative relation to births, in accordance with the observation that increasing industrialisation and services such as education and family planning bring lower birth rates. Services are assumed to have a greater effect on births than the production of goods; the maximum negative effect occurs at twice the 1977 per-capita production, goods and services together reducing the fertility rates to 2.0 from their average 1971 level of about

Table 5

Age-Specific Fertility Rates for Northwestern Ontario, 1971*

15-19	20-24	25-29	30-34	35-39	40-44	45-49
.06001	.18113	.16596	.09411	.03929	.01224	.00015

Table 6

Age-Specific Mortality Rates for Northwestern Ontario, 1971*

	0-4	0	1-4	5-9	10-14	15-19	20-24	25-29	30-34
Male	.00635	.02529	.00120	.00073	.00093	.00180	.00134	.00162	.00300
Female	.00444	.01192	.00250	.00025	.00057	.00055	.00076	.00098	.00147

	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75+
Male	.00234	.00381	.00625	.01023	.01346	.02512	.03571	.05462	.11993
Female	.00254	.00228	.00408	.00648	.01149	.01377	.01879	.03112	.07166

*Betty Macleod and Sabir Shakeel, "The Development of Improved Bases for Forecasting School Age Population Throughout Ontario" (Unpublished Tables).

Table 7

In-Migrants to Northwestern Ontario, 1971

District		0-14	15-24	25-44	45-64	65+
Thunder Bay	Male	936	983	1,058	278	113
	Female	871	758	919	222	117
Rainy River	Male	256	183	269	49	30
	Female	254	167	209	41	29
Kenora	Male	477	507	586	134	51
	Female	439	371	452	118	45
Northwestern Ontario*	Male	1,382	1,391	1,595	375	151
	Female	1,299	1,043	1,345	332	156

Table 8

Out-Migrants from Northwestern Ontario, 1971

District		0-14	15-24	25-44	45-64	65+
Thunder Bay	Male	973	907	1,083	323	160
	Female	812	761	813	274	140
Rainy River	Male	150	188	153	55	28
	Female	139	144	132	46	33
Kenora	Male	564	483	594	172	100
	Female	533	482	526	135	83
Northwestern Ontario*	Male	1,364	1,296	1,512	464	245
	Female	1,219	1,134	1,236	403	217

*Migrants to and from Northwestern Ontario are calculated as the total of the three Districts minus migrants between these Districts.

2.9 (see Table 9, page 43).

Pressure on deaths by the production of food, goods, and services is in a negative relation. Food production has the greatest effect because of the direct relationship between the nutritional quality of food and the health of its consumers. Because the economy of the Region is "open," however, low per-capita food production does not necessarily mean that people will starve, because goods and services can be traded for food. The effect of services levels off above 1.5 times the 1971 per-capita production, as reasonably high health standards are likely to be reached; below 0.5 times 1971 per-capita production the effect again levels off as "services" are provided by friends and neighbours. The production of goods has the smallest effect on deaths except at very low per-capita levels. Without the capital goods necessary for mobility, instruments, facilities, etc., the death rate can be very high (see Table 10, page 43).

The pressures of the production of goods, services, and food on in-migration have positive slopes, whereas the pressures of the production of food and goods on out-migration have negative slopes. The pressure of services on out-migration is different. Improved services can at first increase out-migration by making the population more mobile before local services have improved sufficiently to reduce the desire to leave the Region. The maximum negative effect on in-migration is -1, which occurs at or near production levels of zero. Food production has the greatest effect on migration, because of the use of migrant farm workers and the pressures of high food costs on out-migration (although these effects level off at high and low per-capita levels). Services has a slightly smaller effect, but the positive effect on in-migration and the negative effect on out-migration increase as per-capita production rises to twice its 1971 level. The production of goods has less effect on migration although, like services, its effect increases as per-capita levels rise (see Table 11, page 44).

The other feedback pressure tables relate per-capita production to the desire for further growth, and the participation rates and non-productive time to desired non-participation and desired non-productive time. The tables showing desired further growth all have negative slopes; in other words, the desire for further growth decreases as per-capita production increases. This desire is given an index value between 0 and 10. Services maintains the highest demand throughout its slope, goods the second highest, and food the lowest. At per-capita levels of 1, both the production of goods and services have a positive desired growth (i.e., a desire index greater than 1), while food production has a desired reduction (i.e., a desire index less than 1) (see Table 12, page 45).

There is a positive relation between the participation rate and desired non-participation; that is, desired non-participation increases as the participation rate increases (see Table 13, page 46). Desired non-participation equals 1 when the desired stable participation rate has been reached in each of the male and female primary and secondary labour force groups. These rates are assumed to be as shown in Table 14 (page 46).

Desired non-productive time is in negative relation to non-productive time; that is, as non-productive time increases the desire for non-productive time decreases. Forrester has estimated that under "normal" conditions about 85 percent of the total man-hours available--including those devoted to sleeping, eating, holidays, relaxation, shopping, etc.--are non-productive. When non-productive time equals 85 percent of total man-hours, the desire for non-productive time is assumed to equal 1; that is, no change is desired (see Table 15, page 47).

Table 9

The Feedback Pressure of Per-Capita Production on Births
(for Food, Goods, and Services)

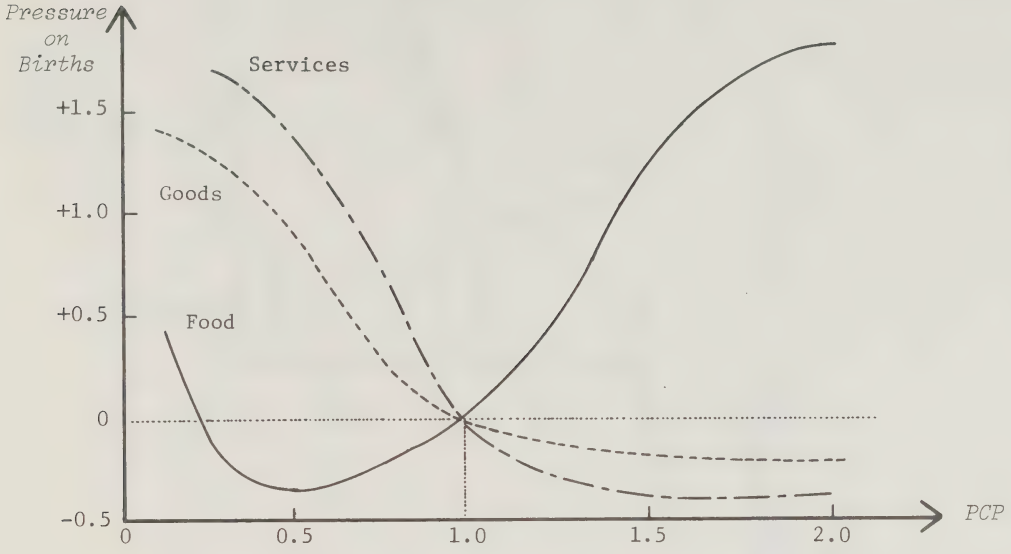


Table 10

The Feedback Pressure of Per-Capita Production on Deaths
(for Food, Goods, and Services)

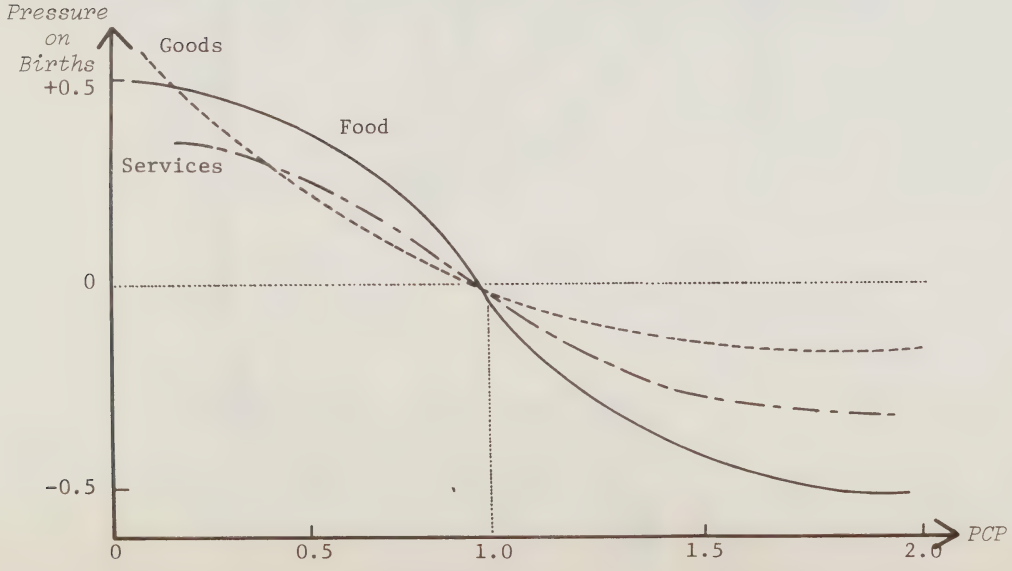


Table 11

The Feedback Pressures of Per-Capita Production on Migration
(for Food, Goods, and Services)

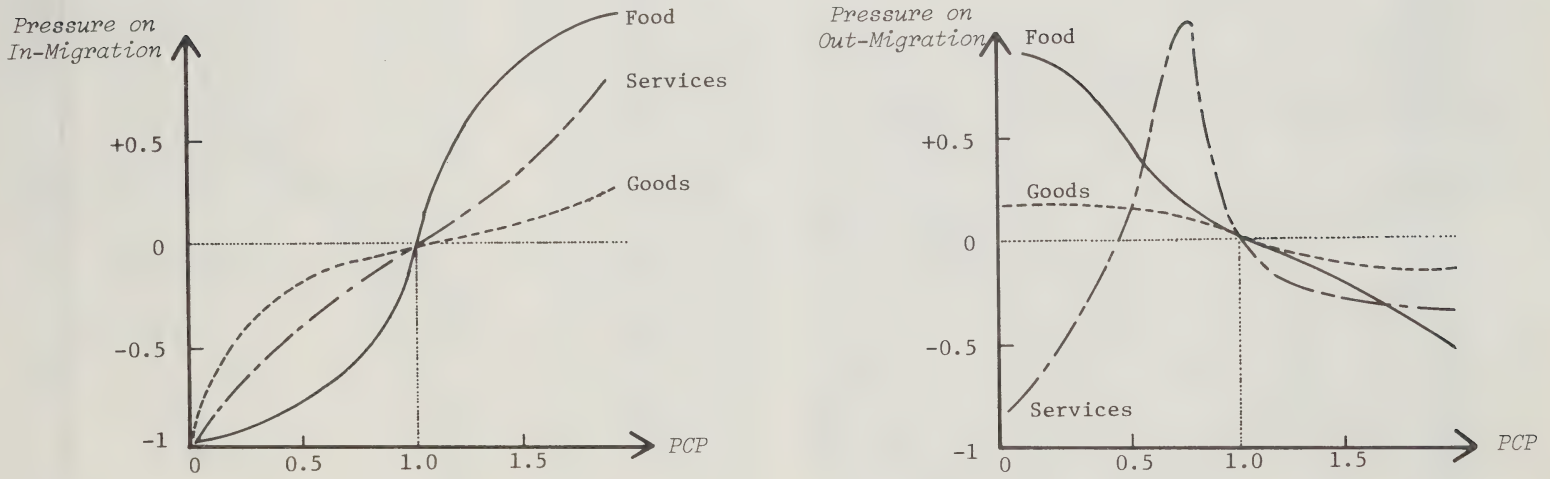


Table 12

Feedback Desire for Further Growth

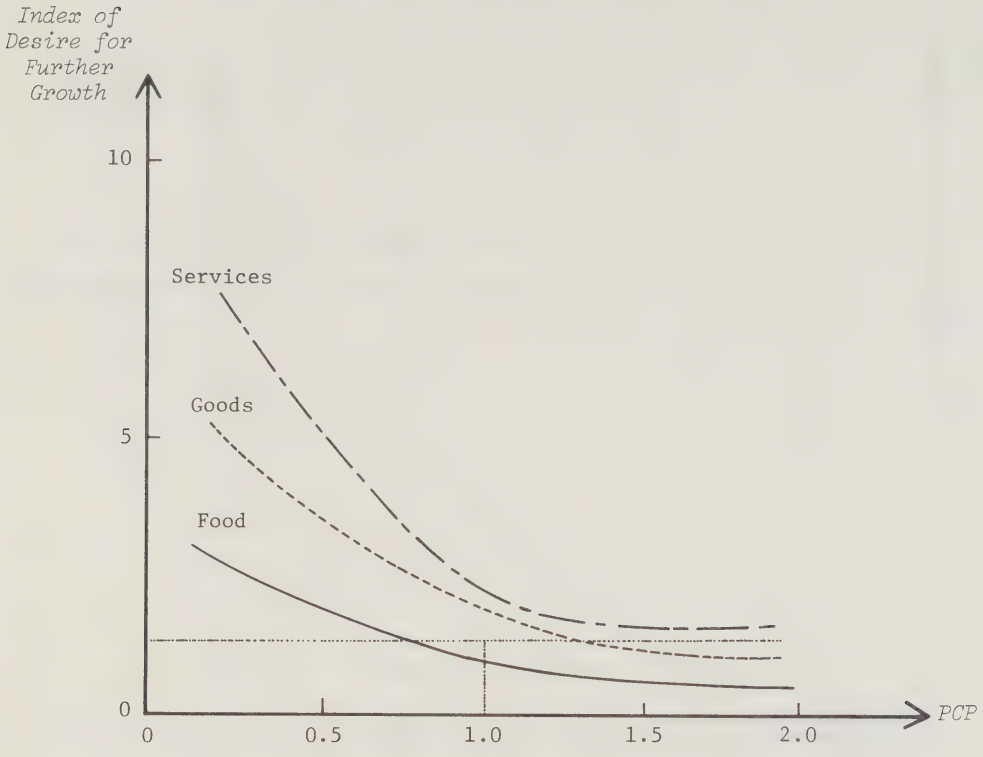


Table 13

Desire for Non-Participation in the Labour Force

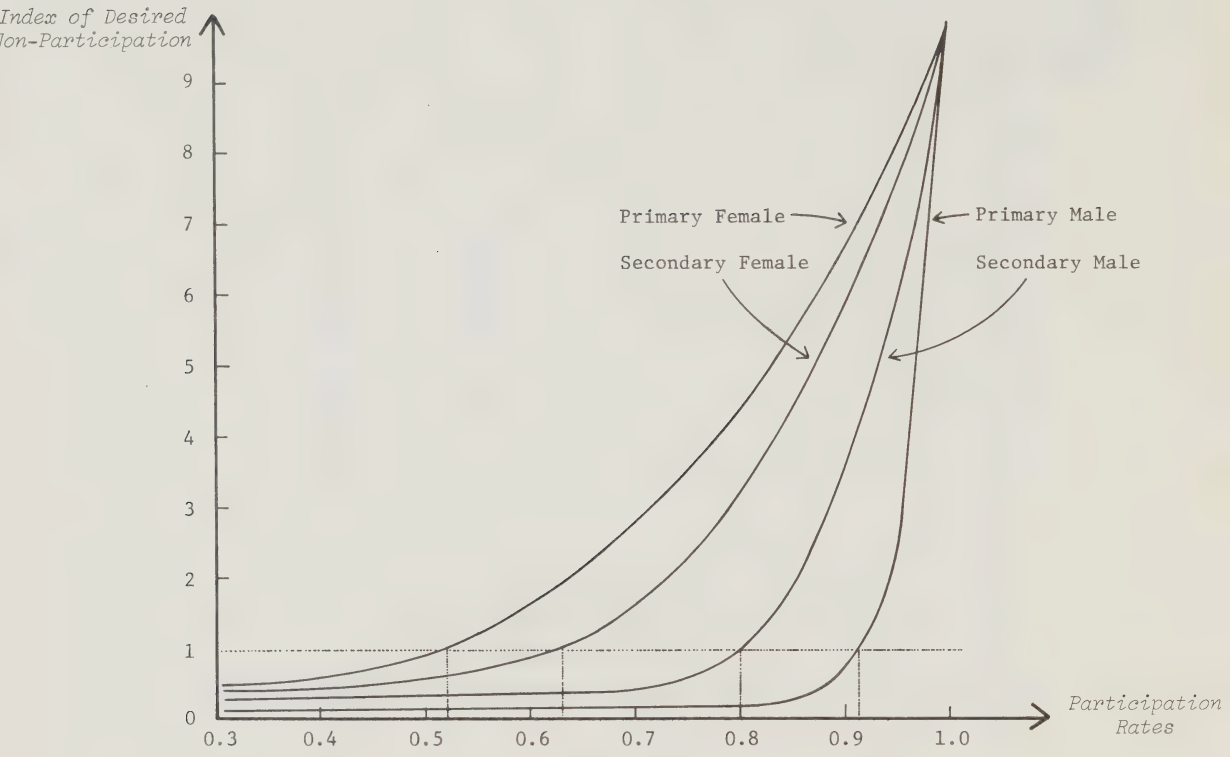


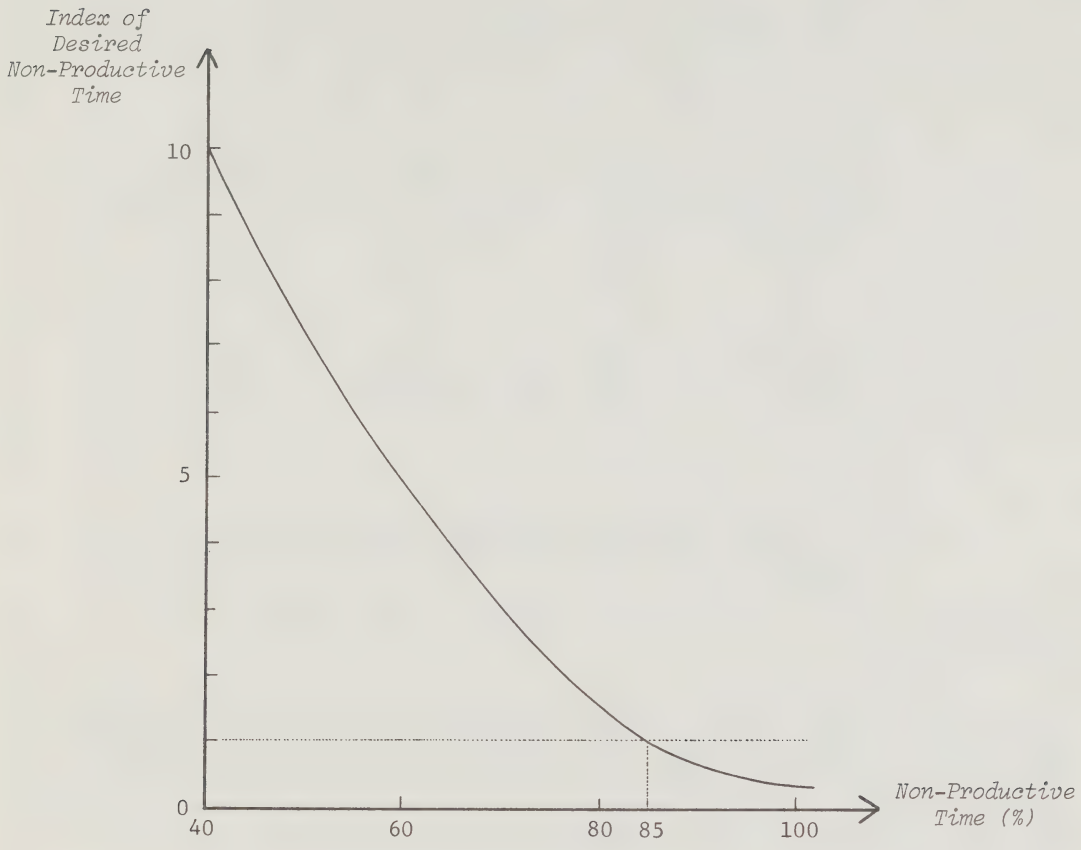
Table 14

Desired Stable Participation Rates

Primary Male	.91
Secondary Male	.80
Primary Female	.52
Secondary Female	.63

Table 15

Desire for Non-Productive Time



4. Exogenous values

The exogenous values used in this model can be divided into four groups: those used in the population sector to a) update the population figures and b) calculate feedback pressures; and those used in the labour sector to c) calculate production and d) calculate feedback pressures.

In updating the population figures the ratio of births by sex is assumed to be .505 males to .495 females. The ratio of male to female live births for the years 1951 to 1971 is shown in Table 16.

Table 16

Ratio of Male to Female Live Births, 1951-1971*

Year	Male	Female	Ratio
1951**	2,177	2,095	.510
1956	2,860	2,713	.513
1961	3,133	3,048	.507
1966	2,363	2,202	.518
1971	2,331	2,127	.523

*Province of Ontario, Vital Statistics, Registrar General's Office, 1951, 1956, 1961, 1966, 1971.

**Does not include the Patricia Portion.

The model uses exogenous tables to distribute feedback pressures in the population sector by age and sex. The distributions of births and deaths in 1961 and 1966 are obtained from the change in age-specific fertility and mortality rates as a percentage of total change between 1961 and 1971 and between 1966 and 1971. The distribution in 1971 is equal for all age and sex groups. Projections of age-specific birth and death rates for 1981[2] are used to calculate the change from 1971 for each age and sex group as a percentage of total change (see Table 17, page 49).

The distribution of feedback pressures on death rates according to five-year age groups was highly variable. Therefore, deaths were aggregated to the same age groupings as migrants--i.e., 0 to 14, 15 to 24, 25 to 44, 45 to 64, and 65+--and the five-year age-specific pressure distributions were considered equal within each migration age grouping. One exception was the 65+ group, in which two-thirds of the pressure was allocated to the 75+ age group and one-sixth each added to the 65-to-69 and 70-to-74 age groups. Within the 0-to-14 group the infant mortality rate was used for age 0, and the rest distributed to the 1-to-4, 5-to-9, and 10-to-14 age groups in proportion to the difference in the death rates for each of these groups in 1971. This procedure was required because the actual death rates vary considerably among these age groups (see Table 18, page 50).

[2]Macleod and Shakeel, "Improved Forecasting."

Table 17

Age and Sex Distributions of the Feedback Pressure on Age-Specific Fertility Rates

	15-19	20-24	25-29	30-34	35-39	40-44	45-49
Fertility Rates in 1971	.06001	.18113	.16596	.09411	.03929	.01224	.00015
Fertility Rates in 1961	.09862	.28938	.23409	.15561	.08325	.02891	.00189
Difference, 1961 to 1971	3,861	10,825	6,813	6,150	4,396	1,667	174
Difference as a Percentage of the Total	.11395	.31945	.20106	.18149	.12973	.04919	.00513
Fertility Rates in 1966	.06552	.20356	.17944	.11196	.06374	.02325	.00192
Difference, 1966 to 1971	551	2,243	1,348	1,785	2,445	1,101	177
Difference as a Percentage of the Total	.05710	.23244	.13969	.18497	.25337	.11409	.01834
Fertility Rates in 1981	.02577	.17569	.16260	.06195	.02266	.00441	.00000
Difference, 1971 to 1981	-3,424	-544	-336	-3,216	-1,663	-783	-15
Difference as a Percentage of the Total	.34305	.05450	.03366	.32221	.16663	.07845	.00150

Table 18

Age and Sex Distributions of the Feedback Pressure on Age-Specific Mortality Rates*

Distribution	0	1-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-45	45-49	50-54	55-59	60-64	65-69	70-74	75+
1961																	
Male	.30682	.00029	.00099	-.00495	.00167	.00167	.00384	.00384	.00384	.00384	.01003	.01003	.01003	-.01003	-.03977	-.03977	.03977
Female	.46791	.00959	-.01113	.00154	-.00718	-.00718	-.00351	-.00351	-.00351	-.00351	-.01721	-.01721	-.01721	-.01721	.05119	.05119	.20477
1966																	
Male	-.10710	.00182	-.00309	-.00455	.01617	.01617	.00504	.00504	.00504	.00504	.02254	.02254	.02254	.02254	.06592	.06592	.26369
Female	.37911	-.01360	.00397	-.00363	-.00159	-.00159	.00451	.00451	.00451	.00451	-.02890	-.02890	-.02890	-.02890	.05161	.05161	.20643
1986																	
Male	.13215	.00433	.00545	.00929	.01105	---	.01089	.02835	.00785	.00929	.02627	.02467	---	.03988	.00913	.04934	.08329
Female	.06407	.00673	---	.00464	.00032	.00497	.00929	.01185	.02146	.00641	.01970	.03460	.07641	.06023	.04197	.09354	.09258

*Calculated from Macleod and Shakeel, "Improved Forecasting," and Statistics Canada, Census Data, 1961, 1966, and 1971.

An initial estimate of the pressure distribution on in-migration and out-migration was made with the taxation data for 1966 and projected back to 1961. These were then adjusted in order to obtain the correct age and sex distributions of the population in 1966 and 1971 in the simulation runs. It should be noted that these distributions are dependent on the values used in the pressure tables. If different values had been used in the tables--e.g., lower figures for in-migration and out-migration--the net migration and changes in the population would have remained the same, but the data for the pressure distribution would have to have been altered to obtain the correct age and sex distributions. The figures that have been selected for the pressure table reflect the 1966 levels of in- and out-migration and of net migration (in- and out-migration figures were not available for 1961 alone). Thus, the pressure distribution table has been set for these migration levels to obtain the correct age and sex distributions of the population for 1966 and 1971 (see Table 19, page 52).

The figures for 1981 reveal straight-line projections for in-migration. The increase of out-migration between 1971 and 1981 is expected to be smaller than the straight-line projections for males 0 to 14 years old and females 25 to 44 years old (both groups had the greatest decrease of out-migration between 1966 and 1971), and larger for males 15 to 24 years old and females 45 to 64 years old.

These age-distribution tables for changes in the migration rates permit the testing of alternative assumptions, particularly changing values, that affect migration to and from the Region. One may test, for example, the attraction of the "frontier" north for prime-working-age males and young families; or the desire of young males and females to seek greater opportunities in Southern Ontario after early industrial advances have allowed them to taste the "good life" in Northwestern Ontario; or the decision of some young couples and retired people to "escape to the country."

A number of exogenous variables are used in calculating production. The first is the productivity of labour, which is shown as a percentage of its 1971 level (see Table 20, page 53).

Unemployment rates, obtained from the same source, are shown in Table 21 (page 53). Unemployment is assumed to remain at 15 percent until 1981. Alternative assumptions can be tested in the model, though such assumptions may produce different figures for the 1981 projections without altering the dynamic effects of the adjustment mechanisms built into the model.

The length of the workday in each sector is assumed to remain constant in the initial "onlooker" forecast, although different assumptions have also been tested in the policy-conditional forecasts (see Appendix III).

Included in the calculation of production levels is a possible limitation of available capital. The potential output is calculated first. The amount of capital required is then calculated from the labour employed and exogenous ratios of capital to labour. A "deficiency" ratio is then obtained by comparing the required capital to the available capital (i.e., if the available capital is four-fifths of the required capital the deficiency ratio is 0.8). The potential output is then reduced by multiplying it by the deficiency ratio. This procedure is applied to the production of goods and services but not that of food.

The ratios of capital to output are 25 in goods production and 15 in services.[3] The ratio of capital to labour in goods production is $250,000 in capital

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[3]These figures are obtained from background data prepared for Lynne Mitchell, "An Economic History of Northwestern Ontario," Northwestern Ontario Manpower Adjustment Study, no. 1 (1978).

Table 19

Age and Sex Distributions of Feedback Pressure on Migration

Age Group	In-Migration			Out-Migration		
	1961-66	1966-71	1971-81	1961-66	1966-71	1971-81
Males						
0-14	.97	.88	.79	.19	.21	.18
15-24	-.24	-.24	-.25	.12	.04	.05
25-44	.20	.22	.24	.22	.27	.35
45-64	.04	.07	.10	.04	.01	.02
65+	.14	.14	.14	-.02	-.03	-.04
Females						
0-14	.73	.69	.65	.23	.21	.19
15-24	-.90	-.86	-.82	.04	.03	.02
25-44	-.02	-.04	-.06	.16	.26	.14
45-64	-.04	-.01	.02	.03	-.01	.06
65+	.12	.15	.18	-.01	.01	.03

Table 20

Productivity as a Percentage of Its 1971 Level in Northwestern Ontario (1961, 1966, 1971, 1976, 1981)*

	1961	1966	1971	1976	1981
Food	.5714	.7857	1	1.1428	1.3571
Goods	.4706	.7647	1	1.0588	1.1765
Services	.8125	.8750	1	1.1250	1.3125

*These figures are obtained from background data prepared for the Northwestern Ontario Manpower Adjustment Study from Statistics Canada, Census Data.

Table 21

Unemployment in Northwestern Ontario (1961, 1971, 1981)

	1961	1971	1981
Unemployment	2.8%	15%	15%

Table 22

Net Capital Availability in Northwestern Ontario ($ Million)

	1961	1966	1971	1981
Goods	.75	.7	.75	1.0
Services	.4	.6	1.2	.8

for each job in manufacturing, mining, pulp and paper, and construction; it is $150,000 for each job in services. Net capital availability is shown in Table 22 (page 53).

There was no way to estimate the actual net capital flows to Northwestern Ontario. Figures were selected that produced an accurate matching of the model with known data for 1966 and 1971. Net capital flows are assumed to increase until 1981 for the production of goods and decrease for services.

The feedback calculation in the labour sector of the model uses exogenous tables for the labour ratios required in each production sector and the adjustment delays for labour reallocation and changes in participation rates. The labour ratios give the ratio of requirement for each of the male and female primary and secondary labour force groups in each production sector. A set of labour ratios for each production sector was selected to produce the correct totals of employment in the four labour force groups (see Table 24, page 55).

The ratio of primary males in goods production is assumed to continue its decline and the ratios for the other three labour force groups are assumed to increase. The ratio of primary males in services will also decline, and the ratio of secondary females will increase.

Adjustment delays depend on the relative sizes of the index of demand for growth of sectoral production and the index of demand for non-participation or non-productive time. If the ratio of these two is as high as 3 or 4, then the required adjustment is three or four times current levels. An adjustment of this size will obviously take a long time. If this ratio were only as high as 0.5, the adjustment would take much less time. The time-delay values used are shown in Table 23.

Table 23

Adjustment Delays for Changes in the Participation Rates and the Movement of Labour Between Production Sectors

Changes in the Participation Rates	25 years
Movement of Labour into or out of food production	4.3 years
Movement of Labour into or out of goods production	4 years
Movement of Labour into or out of services	6.8 years

Table 24

Labour Force Ratios for the Food, Goods, and Services Production Sectors in Northwestern Ontario, 1961, 1971, and 1981

	1961				1971				1981			
	Male		Female		Male		Female		Male		Female	
	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary
Population	31,303	36,038	28,020	30,941	26,955	43,625	25,255	41,285				
Participation Rates	.97	.79	.30	.30	.94	.79	.43	.44				
Labour Force	30,364	28,470	8,406	9,282	25,338	34,464	10,860	18,165				
Unemployment		2.8%				15%						
Employment	29,537	27,694	8,177	9,029	22,033	29,969	9,443	15,796				
Labour Ratios												
Food	.51	.36	.09	.04	.48	.42	.09	.01	.48	.42	.09	.01
Goods	.70	.27	.02	.01	.62	.30	.03	.05	.57	.32	.04	.07
Services	.19	.44	.17	.20	.11	.43	.17	.29	.10	.43	.17	.30
Calculated Employment												
Food	1,383	976	244	108	696	609	130	14				
Goods	19,928	7,687	569	285	15,804	7,647	765	1,274				
Services	8,218	19,030	7,353	8,650	5,532	21,627	8,550	14,585				
Total	29,529	27,693	8,166	9,043	22,032	29,883	9,445	15,873				

APPENDIX III

TESTS OF ALTERNATIVE POLICY INITIATIVES

The following policy initiatives were tested:

1. Increasing the positive pressure on in-migration and the negative pressure on out-migration as per-capita production levels increase.

2. a) Reducing the net flow of capital to the goods sector;
   b) Increasing the net flow of capital to the goods sector.

3. a) Reducing the net flow of capital to the services sector;
   b) Increasing the net flow of capital to the services sector.

4. Reducing the workday in all three production sectors.

5. a) Maintaining 1971 productivity until 1981;
   b) Doubling the 1971 productivity by 1981.

6. Increasing the desire for growth in the food production sector.

7. Requiring higher primary work-force ratios in the goods and services sectors.

1. Increasing production pressures on net in-migration

This policy initiative has more effect on the labour force in Northwestern Ontario than any other but 5. b) (see Table 25, page 57). However, because of the age and sex distributions of the pressures on migration, the net out-migration of those of labour force age (i.e., those between the ages of 15 and 64) is increased. A greater net in-migration to those groups under 15 years of age and over 65 more than compensates for this loss from the labour force, and shows up after a few years as a greater contribution of the natural increase in the population to growth in the labour force.

Out-migration from the labour force at first reduces growth in the labour force. This trend has the additional effect of lessening the decline in the growth of the contribution due to changes in the participation rates. The higher participation rates and population increases offset the increased out-migration, so that the labour force grows after 1978. It should be noted that higher population levels will eventually reduce per-capita levels of production and increase out-migration, re-establishing the original trend in the growth of the labour force. However, this cycle extends beyond the period of time shown here.

2. Changing the flow of capital to the goods sector

Changes in the flow of capital to the goods sector were introduced into the model after 1976 (see Table 26, page 58). It can be seen that varying the flow of capital between 80 percent of its 1976 level and double its 1976 level has no effect on the supply of labour. Changes in the supply of labour to the goods sector are

Table 25

The Effect of Increasing the Production Pressures on Net In-Migration on Growth in the Labour Force and Its Components

Year	Original "Onlooker Forecast"				Effect of the Policy Initiative			
	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates
1971-72	2829	1504	13	1312	2829	1504	13	1312
1972-73	2742	1631	-5	1116	2387	1631	-345	1100
1973-74	2581	1710	-64	935	2243	1760	-453	936
1974-75	2290	1745	-131	676	2046	1896	-533	683
1975-76	1952	1748	-206	411	1864	2035	-624	453
1976-77	1674	1737	-278	216	1724	2194	-724	254
1977-78	1404	1721	-311	-7	1700	2378	-725	48
1978-79	1173	1690	-342	-175	1707	2580	-767	-107
1979-80	977	1650	-372	-302	1759	2786	-805	-222
1980-81	802	1604	-398	-405	1842	2983	-830	-311

Table 26

The Effect of a Changed Flow of Capital to the Goods Sector on Growth in the Labour Force and Its Components

Year	Original "Onlooker Forecast"				Effect of the Policy Initiative			
	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates
1971-72	2829	1504	13	1312				
1972-73	2742	1631	-5	1116				
1973-74	2581	1710	-64	935				
1974-75	2290	1745	-131	676				
1975-76	1952	1748	-206	411	1952	1748	-206	411
1976-77	1674	1737	-278	216	1674	1737	-278	216
1977-78	1404	1721	-311	-7	1404	1721	-311	-7
1978-79	1173	1690	-342	-175	1173	1690	-342	-175
1979-80	977	1650	-372	-302	977	1650	-372	-302
1980-81	802	1604	-398	-405	802	1604	-398	-405

clearly not limited by the availability of capital.

3. Changing the flow of capital to the services sector

Reducing the flow of capital to the services sector to half its 1976 level decreases the growth in the labour force (see Table 27, page 60). It also decreases the contribution of the natural increase in population, increases net in-migration to the work-force, and causes participation rates to decline more rapidly. The overall trend remains the same despite these changes.

Increasing the flow of capital has the opposite effect on the contribution of the natural increase in population, though the general trend is otherwise the same (see Table 28, page 61). The decline is expected to continue in the growth of the labour force, the contribution of the natural increase in population, the contribution of net migration, and growth in the participation rates. The most significant change is that the actual decline in the participation rates is delayed for a number of years.

4. Reducing the workday

The workday was reduced from eight hours to six in food production, from five hours to four in goods production, and from four hours to three in services (see Table 29, page 62). As a result of this policy the participation rates and the growth in the labour force diminish less quickly, though the steady decline continues. This trend is to be expected since greater participation and a larger labour force are likely to result when employed persons work fewer hours. Net out-migration is also lower and the contribution of the natural increase in population is greater. As in policy number 1, above, the greater population is likely to give rise to greater out-migration after 1980 and return the growth of the labour force to its previous level.

5. Changing the productivity

If there is no gain in productivity between 1971 and 1981, net out-migration from the labour force will increase significantly, and the contribution of the natural increase in population will diminish. A slower decline in the growth of the contribution of changes in the participation rates cannot offset these effects, and the growth in the labour force will decline more rapidly (see Table 30, page 63). As a result of this policy the reduction in the size of the growth of the labour force may occur earlier.

If productivity reaches twice its 1971 level by 1981, the growth in the labour force will decline much less rapidly and the contribution of the natural increase in population will rise substantially (see Table 31, page 64). Net in-migration will rise instead of falling. However, the contribution of changing participation rates drops much more quickly and offsets other gains. Beyond the time period shown here the greater net in-migration will again cause higher population levels to reduce per-capita production and decrease in-migration and the growth of the labour force. The trend is thus once more delayed but not altered.

6. Increasing the desire for growth in the food sector

An increased desire for growth in the food sector brings about a slightly larger increase in the labour force and a greater contribution of the natural increase in the population to the labour force. It also reduces net out-migration.

Table 27

The Effect of Reducing the Flow of Capital to the Services Sector on Growth in the Labour Force and Its Components

Year	Original "Onlooker Forecast"				Effect of the Policy Initiative			
	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates
1971-72	2829	1504	13	1312				
1972-73	2742	1631	-5	1116				
1973-74	2581	1710	-64	935				
1974-75	2290	1745	-131	676				
1975-76	1952	1748	-206	411	1808	1748	-206	266
1976-77	1674	1737	-278	216	1406	1731	-276	-49
1977-78	1404	1721	-311	-7	1132	1705	-304	-268
1978-79	1173	1690	-342	-175	878	1665	-329	-458
1979-80	977	1650	-372	-302	634	1612	-349	-629
1980-81	802	1604	-398	-405	418	1550	-364	-768

Table 28

The Effect of an Increased Flow of Capital to the Services Sector on Growth in the Labour Force and Its Components

Year	Original "Onlooker Forecast"				Effect of the Policy Initiative			
	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates
1971-72	2829	1504	13	1312				
1972-73	2742	1631	-5	1116				
1973-74	2581	1710	-64	935				
1974-75	2290	1745	-131	676				
1975-76	1952	1748	-206	411	1952	1748	-206	411
1976-77	1674	1737	-278	216	1731	1737	-278	272
1977-78	1404	1721	-311	-7	1577	1723	-311	165
1978-79	1173	1690	-342	-175	1460	1697	-345	107
1979-80	977	1650	-372	-302	1347	1667	-381	61
1980-81	802	1604	-398	-405	1250	1634	-420	36

Table 29

The Effect of a Reduced Workday on Growth in the Labour Force and Its Components

Year	Original "Onlooker Forecast"				Effect of the Policy Initiative			
	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates
1971-72	2829	1504	13	1312	2829	1504	13	1312
1972-73	2742	1631	-5	1116	2902	1674	49	1178
1973-74	2581	1710	-64	935	2854	1765	35	1055
1974-75	2290	1745	-131	676	2653	1815	-5	842
1975-76	1952	1748	-206	411	2340	1861	-54	532
1976-77	1674	1737	-278	216	2049	1892	-96	253
1977-78	1404	1721	-311	-7	1877	1924	-98	51
1978-79	1173	1690	-342	-175	1727	1956	-124	-105
1979-80	977	1650	-372	-302	1618	1994	-155	-221
1980-81	802	1604	-398	-405	1590	2028	-137	-301

Table 30

The Effect of No Gain in Productivity Between 1971 and 1981 on Growth in the Labour Force and Its Components

Year	Original "Onlooker Forecast"				Effect of the Policy Initiative			
	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates
1971-72	2829	1504	13	1312	2829	1504	13	1312
1972-73	2742	1631	-5	1116	2680	1584	-68	1164
1973-74	2581	1710	-64	935	2493	1633	-172	1033
1974-75	2290	1745	-131	676	2154	1651	-265	768
1975-76	1952	1748	-206	411	1757	1637	-348	468
1976-77	1674	1737	-278	216	1338	1582	-426	182
1977-78	1404	1721	-311	-7	1029	1501	-451	-21
1978-79	1173	1690	-342	-175	762	1405	-468	-175
1979-80	977	1650	-372	-302	527	1296	-478	-290
1980-81	802	1604	-398	-405	325	1180	-484	-372

Table 31

The Effect of Doubling the Productivity Between 1971 and 1981 on Growth in the Labour Force and Its Components

Year	Original "Onlooker Forecast"				Effect of the Policy Initiative			
	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates
1971-72	2829	1504	13	1312	2829	1504	13	1312
1972-73	2742	1631	-5	1116	2786	1692	45	1050
1973-74	2581	1710	-64	935	2622	1775	27	820
1974-75	2290	1745	-131	676	2378	1819	-9	568
1975-76	1952	1748	-206	411	2079	1858	-67	289
1976-77	1674	1737	-278	216	1926	1882	-124	167
1977-78	1404	1721	-311	-7	1841	1950	-109	0
1978-79	1173	1690	-342	-175	1943	2033	119	-209
1979-80	977	1650	-372	-302	1970	2131	277	-438
1980-81	802	1604	-398	-405	1879	2238	321	-680

The contribution of changing participation rates remains higher until 1975-76, but drops more rapidly thereafter so that there is little change by 1981 (see Table 32, page 66).

7. Requiring higher primary work-force ratios in the goods and services sectors

If higher labour force ratios are required for primary workers in these two sectors, the growth of the labour force is greater for a few years but then drops more rapidly (see Table 33, page 67). The same is true for the contribution of changes in participation rates. Migration and the contribution of the natural increase in population are almost unaffected by this policy.

In conclusion, it is clear that, while the trends demonstrated in the initial "onlooker forecast" can be shifted to occur sooner or later or at greater or lesser intensity, the cyclical pattern resulting from the feedback processes built into the model continues unaltered. A summary of the effects of each of the policy initiatives on the size of the labour force in Northwestern Ontario in 1981 is given in Table 34 (page 68).

Table 32

The Effect of a Greater Desire for Growth in the Food Sector on Growth in the Labour Force and Its Components

Year	Original "Onlooker Forecast"				Effect of the Policy Initiative			
	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates
1971-72	2829	1504	13	1312	2838	1504	13	1321
1972-73	2742	1631	-5	1116	2805	1642	40	1123
1973-74	2581	1710	-64	935	2689	1729	18	943
1974-75	2290	1745	-131	676	2438	1775	-20	684
1975-76	1952	1748	-206	411	2143	1797	-72	418
1976-77	1674	1737	-278	216	1892	1809	-125	209
1977-78	1404	1721	-311	-7	1662	1818	-140	-16
1978-79	1173	1690	-342	-175	1476	1816	-155	-186
1979-80	977	1650	-372	-302	1323	1806	-170	-313
1980-81	802	1604	-398	-405	1189	1788	-184	-416

Table 33

The Effect of Requiring Higher Primary Work-Force Ratios in the Goods and Services Sectors on Growth in the Labour Force and Its Components

Year	Original "Onlooker Forecast"				Effect of the Policy Initiative			
	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates	Growth of the Labour Force	Contribution of Natural Increases in the Population	Contribution of Net Migration	Contribution of Changes in the Participation Rates
1971-72	2829	1504	13	1312	2829	1504	13	1312
1972-73	2742	1631	-5	1116	2712	1631	-5	1086
1973-74	2581	1710	-64	935	2527	1711	-64	880
1974-75	2290	1745	-131	676	2328	1747	-132	713
1975-76	1952	1748	-206	411	1992	1753	-206	445
1976-77	1674	1737	-278	216	1733	1747	-277	263
1977-78	1404	1721	-311	-7	1459	1736	-308	31
1978-79	1173	1690	-342	-175	1148	1710	-338	-223
1979-80	977	1650	-372	-302	889	1672	-368	-414
1980-81	802	1604	-398	-405	664	1627	-396	-567

Table 34

A Summary of the Forecasts of the Labour Force in Northwestern Ontario in 1981 Obtained with Different Assumptions

Policy	Population 1981	Net Migration 71-76	Net Migration 76-81	Participation Rates, 1981 Male P	Participation Rates, 1981 Male S	Participation Rates, 1981 Female P	Participation Rates, 1981 Female S	Labour Force, 1981 Male P	Labour Force, 1981 Male S	Labour Force, 1981 Female P	Labour Force, 1981 Female S	Labour Force, 1981 Total	% Change From Initial Run
Initial Run	248,553	-1,443	-3,523	.9007	.7958	.4924	.5285	31,526	36,737	16,448	23,170	107,880	----
1. Increased Production Pressures on Net In-Migration	285,112	+9,678	+28,335	.8984	.7967	.5034	.5370	34,318	38,654	14,289	22,296	109,557	+1.55
2. a) Reduced Capital to the Goods Sector	248,553	-1,443	-3,523	.9007	.7958	.4924	.5285	31,526	36,737	16,448	23,170	107,880	0
b) Increased Capital to the Goods Sector	248,553	-1,443	-3,523	.9007	.7958	.4924	.5285	31,526	36,737	16,448	23,170	107,880	0
3. a) Reduced Capital to the Services Sector	247,917	-1,443	-4,211	.8969	.7802	.4817	.5178	31,240	35,988	16,116	22,830	106,174	-1.58
b) Increased Capital to the Services Sector	248,935	-1,443	-3,131	.9043	.8069	.5005	.5381	31,746	37,251	16,716	23,502	109,215	+1.24
4. Reduced Workday	262,367	+1,750	+6,921	.9072	.7989	.5009	.5359	34,798	38,210	16,435	22,451	111,894	+3.72
5. a) No Productivity Gain 1971-1981	237,533	-4,406	-11,076	.9055	.7977	.4938	.5272	29,254	35,593	16,743	23,762	105,352	-2.34
b) Double Productivity 1971-1981	274,164	+1,906	+15,749	.8886	.7910	.4881	.5289	35,452	38,098	15,948	22,211	111,709	+3.55
6. Increased Desire for Growth in the Food Sector	255,901	+511	+1,446	.8993	.7956	.4937	.5299	33,064	37,467	16,430	22,951	109,912	+1.88
7. Greater Primary Labour Force Ratios	248,567	-1,462	-3,492	.9193	.7811	.5144	.5090	32,180	36,060	17,186	22,313	107,739	-0.13

Northwestern Ontario Manpower Adjustment Study

Component Studies

1. **An Economic History of Northwestern Ontario**
2. **Projections of Labour Supply by Occupation in Northwestern Ontario, to 1981**
3. **Projections of Enrolment and Graduations from Secondary and Post-Secondary Institutions in Northwestern Ontario, to 1981**
4. **Labour Market Intentions of Graduating Students from Post-Secondary Institutions in Northwestern Ontario**
5. **Projections of Total Labour Force in Northwestern Ontario, to 1981**
6. **Results of a Manpower Survey of the Mineral and Forest Products Industries in Northwestern Ontario**
7. **Projections of Manpower Requirements by Occupation and Industry for Northwestern Ontario, to 1981**
8. **Aspects of Migration in Northwestern Ontario, 1966-71**
9. **Why People Move from Northwestern Ontario**
10. **Labour Turnover and Absenteeism in Selected Industries: Northwestern Ontario and Ontario**

Project Directors

Ontario Ministry of Labour
Research Branch

Ontario Ministry of Labour
400 University Avenue
Toronto, Ontario
M7A 1T7

Dr. Farid Siddiqui
Chief Economist
Manpower and Employment Opportunities
Research Branch

Employment and Immigration Canada

100 Elm Street East
City Centre
Sudbury, Ontario
P3C 1FA

Mr. Mel Soucie
District Economist—Northern Ontario
Canada Employment and Immigration Commission